A Use of Materials, Components & Finishes in Engineering Design

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:UUM PUMPS

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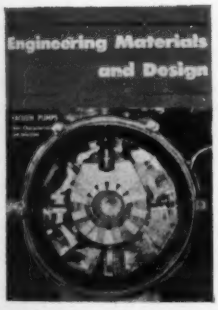

Man's-eye view of tantalum heating elements and molybdenum radiation shields in a high-vacuum unit used to measure the elastic constants of metals, at the Union Carbide Corp. metals research laboratory in the U.S.A.

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ISSUE AT A GLANCE

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Survey of the technology, characteristics and accessories of modern vacuum pumps.

By **M. E. Boston**

THERMOPLASTICS IN DESIGN 816

The author explains how far it is possible to use standard methods of design when dealing with thermoplastics.

By **P. I. Vincent**

COMBATING SELF-EXCITED ROTOR VIBRATION 826

Showing how to deal with the problems arising from self-excited rotor vibrations initiated by the action of the lubricating film in journal bearings.

By **A. Tondl**

IMPORTANCE OF CREEP TO THE DESIGNER 832

Description of the modern equipment in the Electrical Research Association's new creep laboratory.

By Dr. A. Chitty and W. H. Devenish

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POMPES A VIDE — CARACTERISTIQUES ET SELECTION

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Etude sur la technologie, les caractéristiques et les accessoires des pompes à vide modernes.

LUTTE CONTRE LES VIBRATIONS SPONTANEES DES ROTORS

A. Tondl page 826

La tendance, à l'heure actuelle, est d'augmenter le champ d'opération des systèmes à turbines au delà de la première vitesse critique du rotor. Cet article nous montre comment on peut s'attaquer au danger des vibrations spontanées du rotor, engendrées par l'action de la fine couche de lubrifiant des paliers et portées.

MESURE DE LA DEFORMATION DE L'ACIER UTILISE DANS LA CONSTRUCTION DES CENTRALES ELECTRIQUES

A. Chitty et W. H. Devenish page 832

Les auteurs décrivent l'équipement moderne d'un nouveau laboratoire d'étude du "creep des métaux" construit dernièrement en Grande-Bretagne. Ces appareils permettront d'entreprendre des recherches fondamentales sur les aciers.

METHODES DE DESSIN POUR THERMOPLASTIQUES

P. I. Vincent page 816

L'auteur explique les limites des méthodes actuelles de dessin dans le domaine des thermoplastiques et indique quelques aspects additionnels qui doivent être pris en considération.

Kurzreferate

KENNDATEN UND AUSWAHL VON VAKUUMPUMPEN

H. E. Boston Seite 810

Eine Übersicht über die Technik, Kenndaten und das Zubehör von modernen Vakuumpumpen.

BEKAMPFUNG SELBSTERREGTER ROTORVIBRATIONEN

A. Tondl Seite 826

Der moderne Trend geht auf die Erhöhung des Betriebsbereichs von Turbinen über die erste kritische Drehzahl des Rotors. Der Artikel zeigt, wie die Gefahr der selbsterzeugten Rotorvibrationen durch die Wirkung des Schmierfilms in den Lagern überwunden werden kann.

MESSUNG DES KRIECHENS VON STAHL BEIM BAU VON KRAFTWERKEN

A. Chitty und W. H. Devenish Seite 832

Eine Beschreibung der modernen Einrichtung in einem Laboratorium zum Studium des Kriechverhaltens, das vor kurzem in Grossbritannien eingerichtet wurde. Die Einrichtung gestattet die Durchführung von langzeitigen Forschungsarbeiten mit Stahl.

KONSTRUKTIONSMETHODEN MIT THERMOPLASTEN

P. I. Vincent Seite 816

Der Verfasser erklärt, wie es möglich ist, normale Konstruktionsmethoden mit Thermoplasten zu verwenden und zeigt einige der zusätzlichen, in Betracht zu ziehendem Aspekte.

Резюме

ВАКУУМ-НАСОСЫ, ИХ ХАРАКТЕРИСТИКИ И ИХ ВЫБОР

Г. Э. Бостон Стр. 810

Обзор технологии, характеристик и вспомогательных устройств современных вакуум-насосов.

БОРЬБА С САМОВИБРАЦИЕЙ РОТОРОВ

А. Тондль Стр. 826

В настоящее время наблюдается тенденция расширять рабочий диапазон турбин с превышением первой критической скорости вращения ротора. В данной статье указываются способы борьбы с опасностью самовибрации ротора, вызванной действием пленки смазочного вещества в подшипниках скольжения.

ИЗМЕРЕНИЯ ПОЛЗУЧЕСТИ СТАЛИ, ПРИМЕНЯЕМОЙ В СТРОИТЕЛЬСТВЕ ЭЛЕКТРОСТАНЦИИ

А. Читти и У. Х. Девениш Стр. 832

Описание новейшего оборудования, имеющего в лаборатории по проблемам ползучести, недавно открытой в Англии. Эта аппаратура сделает возможными долгосрочные исследования сталей в будущем.

МЕТОДЫ КОНСТРУКЦИИ ДЛЯ ТЕРМОПЛАСТОВ

Л. У. Винсит Стр. 816

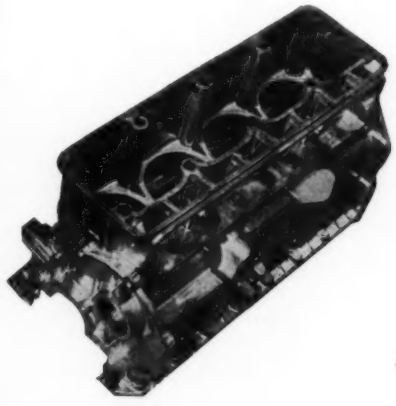
Автор показывает, насколько применимы стандартные методы конструкции для термопластов, и намечает некоторые дополнительные аспекты, которые необходимо учитывать.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

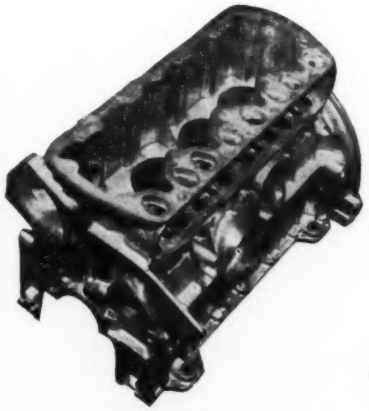
Die-Cast Engine Cylinder Blocks

With the increasing use of aluminium for automobile engines, serious consideration has been given to the problems associated with their production by pressure-die-casting methods, and recently a large 2,200-ton die-casting machine designed and made by A. Triulzi of Milan (Italy) was shipped to the U.S.S.R.



Volga cylinder block

where it is to be used for the production of the four-cylinder block for the Volga car. This die casting weighs a little under 50 lb. as it leaves the machine, and about 40 lb. as trimmed, the alloy used containing a high percentage of silicon. It is expected that the blocks will be produced at the rate of between twenty and twenty-two castings per hour.



Skoda cylinder block

Also illustrated is the die-cast cylinder block for the Czechoslovak Skoda car. Samples of these have been made on the same machine and sent to the Skoda works for evaluation tests.

Monomer Casting

A new process for producing massive nylon shapes can be carried out at atmospheric pressure and is similar to the conventional techniques used in the casting of metals. Described as monomer casting, it is expected to open up new markets for nylon in heavy industries now using metal castings.

Polypenco Ltd., through their United States parent company, have acquired the rights to use the process for casting nylon shapes in the U.K. and have now developed the technology to production on a commercial scale.

The material, designated as MC nylon, is a type 6 nylon formulation. Until now the inherent advantages of nylon have been unavailable in large components because of the high tooling costs and the processing limitation of conventional moulding methods. In the casting of MC nylon, direct production of the finished nylon parts from the monomer eliminates five steps in the processing cycle and thereby enables large parts to be made at lower costs than hitherto; expensive moulds required in conventional injection or extrusion moulding of nylon polymers are eliminated. The new process will not, however, compete with injection moulding now widely used for mass production of small parts.

The largest monomer cast MC nylon parts produced to date have been semi-finished symmetrical shapes in the 500 to 700 lb. range. A steel casting of the same size would weigh over 2 tons. It is expected that a progressive increase in the size range capabilities will be possible.

Superconducting Transformers

Because of the important role played by electrical resistance in the economics of transformers, the use of superconductors in place of copper wires has been an attractive prospect ever since superconductivity was discovered. The main reason why superconducting wires have not been used for this purpose lies in the nature of superconductivity itself. Superconductors cannot withstand strong magnetic fields. When they are subjected to fields the power of which is a small fraction of those usually found in transformer coils, electrical resistance reappears.

To overcome this difficulty an alternative approach to the use of a special superconductor capable of withstanding strong magnetic fields, is to prevent the build-up of the field within the coil or conductors.

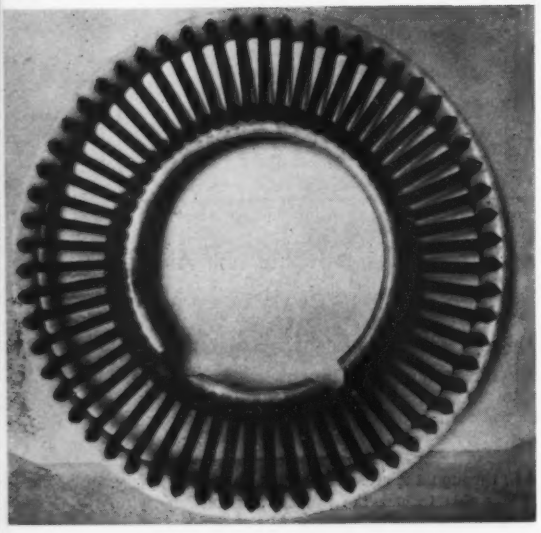
In an analysis by Arthur D. Little Inc. it was found that superconducting transformers are feasible provided that (a) the core is operated at normal temperatures, to reduce refrigerator load, and (b) the primary and secondary windings are interleaved, to prevent premature quenching of superconductivity by magnetic fields within the windings.

Potential advantages of these devices include small losses, high power ratings and low reactance factors.

Bound copies of Data Sheets 62 and 63 (Standard Bolts, Screws, Nuts and Washers for Threads up to 1·0 in. dia.) are now available from Heywood & Co. Ltd., Drury House, Russell Street, Drury Lane, W.C.2.

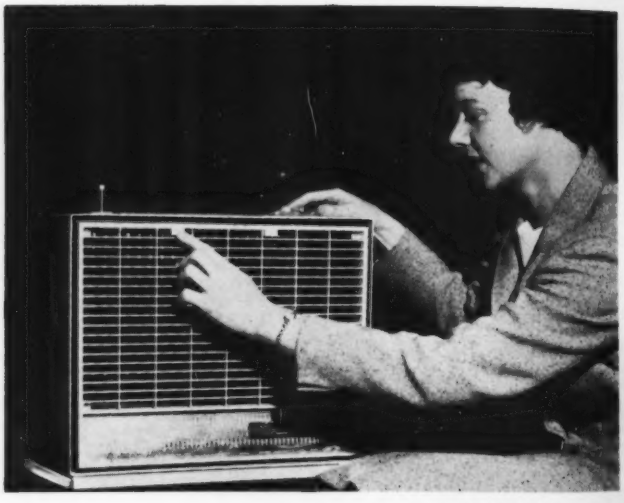
PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN



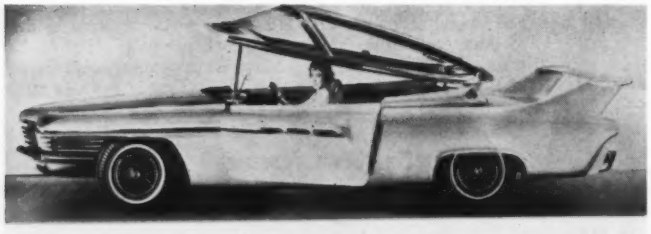
SWIRL VANE FOR HELICOPTER

This plastics swirl vane ring is moulded in Marco resin (Scott Bader & Co. Ltd.), and forms part of the power unit of a Westland helicopter.



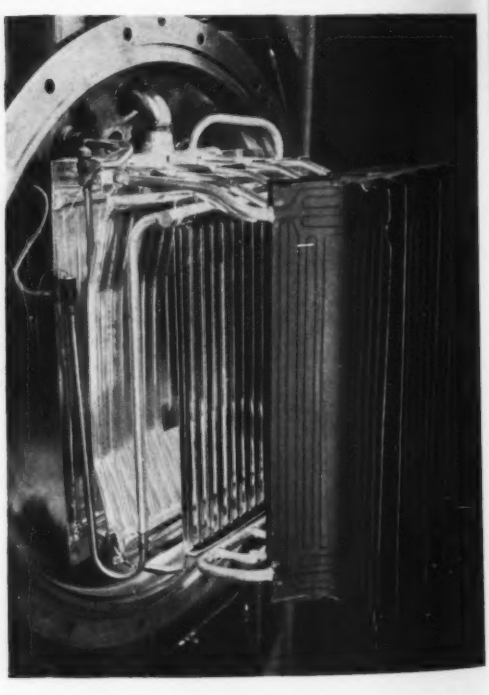
FRESH, CLEAN AIR

The Wright Bell-air conditioner shown above was developed from the air-conditioning unit in U.S. atomic submarines. Air is filtered using activated charcoal, forced through an impregnated "germ guard", and finally washed, cooled and dehumidified. This conditioner is being marketed in the U.K. by Sales Organisers Ltd.



CAR FOR THE FUTURE

Two views of the new Chrysler experimental turbine-powered car, named the Turboflite. The car is fitted with an air brake located between the two rear fins, and the entire canopy rises whenever either door is opened. The regenerative turbine engine develops 140 b.h.p. at 39,000 r.p.m., and weighs only 450 lb. including the reduction gearing and the starter generator.

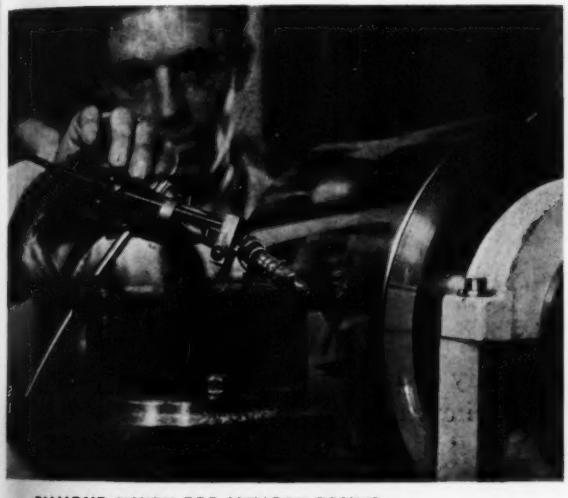


ULTRA-HIGH VACUUM

This array of tubed shields, chevrons and condenser, used by Arthur D. Little Inc. for removing gases at very low pressures to produce vacuums required for space-simulation chambers, is cooled by liquid nitrogen and very cold helium gas.

JET TEST

Known as the Aqua-jet, this Boeing jet-propelled twin-hulled test craft is used as a high-speed floating laboratory for evaluating hydrofoil characteristics. The test foil is mounted on the forward structure between the hulls; the observer is stationed in one cockpit and the driver in the other.



DIAMOND FINISH FOR MEMORY DRUMS

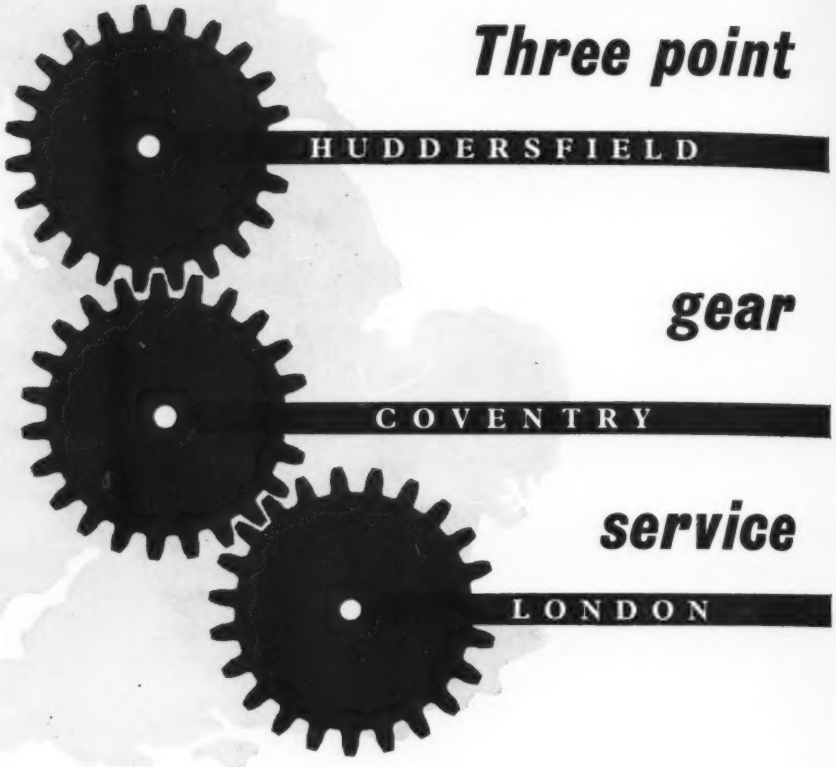
Aluminium-alloy memory drums made by Sperry Gyroscope Co. Ltd. are coated with a layer of copper plate which is subsequently diamond turned (see above) to give a surface finish of not more than 8 micro-inches CLA—the drum is then nickel plated 0.0002 in. thick. In a second type of finishing process, the outside diameter of the drum itself is diamond turned, and a mixture of epoxy resin and ferric oxide is then sprayed on in excess of the finished thickness. Diamond turning is used to reduce the thickness of the coating to that finally required.

AUTOMATIC TRANSMISSION

Pressure-die-cast casings for the new Borg-Warner model 35 transmission system, shown in their new factory. The transmission, which is for medium-size cars, is fully automatic and incorporates two fine-mesh cadmium-plated filters specially designed and produced by Intermit Ltd. The power installation for the new factory was done by British Insulated Callender's Cables Ltd.

NEW DICTATING MACHINE

This Agavox Model 2 dictating machine is only 3 in. high, and will fit into a briefcase; its appearance design is the work of Count Sigvard Bernadette. This miniaturisation has been made possible by the use of transistors and printed circuits.



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Flexible Concrete

The recent launching of the 34-ft. motor cruiser *Tradewind* may have been the first occasion on which an old-established material entered into a new phase of application, since the hull of this boat (designed and built by Windboats Ltd., of Wroxham, Norfolk) was made entirely of concrete. The use of this material in a boat hull is undoubtedly a severe test, since the stresses imposed are of a complex nature—any material which survives such a test is likely to find ready application in other spheres where the stresses are more readily assessed.

The use of concrete for hulls is not new, as many slab-sided craft were made from it during the war; what is new, however, is that this is the first time that three-dimensional contours have been obtained with a hull of less than 1 in. thick.

Tradewind is the result of successful combination of the arts of traditional boat-building and the academic studies on concrete technology carried out by Mr. K. Newman of Imperial College, London. The builders and Mr. Newman are rightly not saying too much at this stage, since the success of the application of Seacrete, as the material is called, lies not so much in the composition but in the process, in which meticulous care has been taken to ensure rigid adherence to a set schedule of operations. Seacrete is cheap, impervious to water, non-corrosive and fireproof, and more important is also flexible. It is intended to demonstrate this feature at the 1962 Boat Show.

Mr. T. M. Hagenbach, director of Windboats Ltd., has no intention of confining the use of Seacrete to boatbuilding. If the forthcoming trials provide the evidence expected, then the material will be used for other applications. The U.S.S.R. has been experimenting for some time with concrete for large machine tools, with some degree of success, and there it little doubt that Seacrete may provide a useful start to investigating similar possibilities in this country, where considerable effort is needed in many directions in order to keep down prices.

Electricity Transmission Research

In his inaugural address as chairman of the supply section of the Institution of Electrical Engineers, Dr. Forrest, director of the Central Electricity Research Laboratories, observed that, broadly speaking, the transmission voltage has been doubled every 20 years. Figures indicated that the choice of voltage through the years has not been far wrong, and the forecast for 1980 was that we should require 550 kV.

While nuclear, thermoelectric power, or some new means of generating electricity may make local generation economic and render the transmission system redundant, there were still many interesting problems to overcome in the present system. Corona discharge which occurs as the result of increased line voltage, leads to loss of power and the generation of radio noise which can interfere with broadcasting and television reception. The solution to this problem lies in the use of a bundle of two, three or four conductors. Although first suggested in 1932, many transmission engineers were slow to accept bundle type conductors and it was not until about 1950 that they were generally recognised as being the best system for voltages of 300 kV and above.

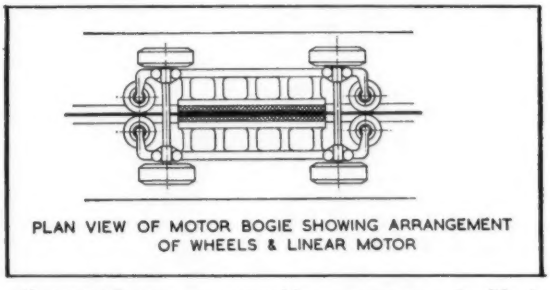
Considerable research has been carried out on the phenomenon of the oscillation of overhead line conductors which is thought to be associated with aerodynamic lift generated by a steady horizontal wind. Research has indicated that this lift can be reduced by using a conductor with a smooth cylindrical outer surface, but it is not known whether this will offer a complete cure.

Dr. Forrest concluded his address by examining the possibilities of applying the principles of superconduction to the design of transformers and cables. This has been made possible through the discovery by the Bell Telephone Laboratories of a niobium-tin alloy which retains its superconductivity in fields of up to 100,000 gauss.

Improving the Railroad System

In a recent paper to the Institution of Mechanical Engineers, Dr. F. T. Barwell suggested that in their present context, if motorways are not to expand indefinitely, a distinct and attractive quality must enter into the competing service, and speeds must be high enough to exert a compelling attraction. Whilst the conventional railway has been shown to be capable of speeds in excess of 200 m.p.h. such traffic would have to be segregated from normal operation. This opens the way for alternative techniques which may be more economical and afford a greater assurance of safety. On the Paris-Metro, vehicles have been arranged to run on pneumatic tyres and to be guided by pneumatic-tyred wheels with axles in the vertical direction. The problem of points and crossings has been avoided, together with dangerous consequences of failure by tyre blow-outs, by the retention of the steel rails of normal gauge and of conventional wheels which are normally clear of these. At the ends of the railways where points and crossings are required, it is only necessary to allow the main wooden rail to fall away so that the junction can be negotiated as normally with steel wheel and rail.

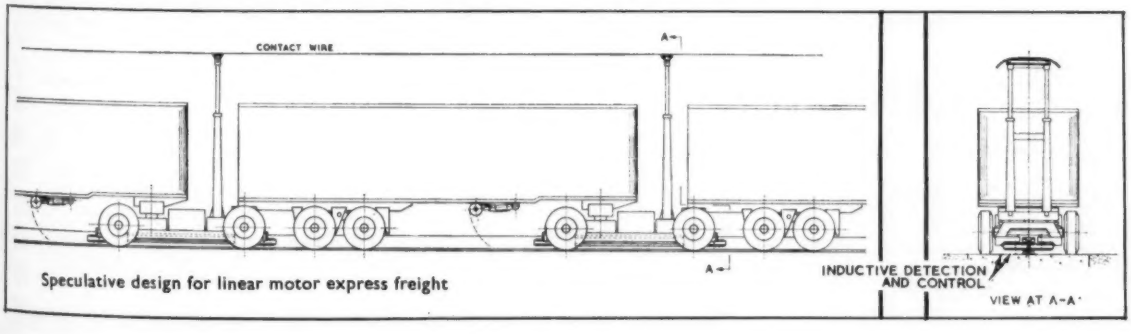
The possibility exists of solving the problem of interchange of wheel and rail and the arrangement illustrated envisages the possibility of operating quite conventional road vehicles.



PLAN VIEW OF MOTOR BOGIE SHOWING ARRANGEMENT OF WHEELS & LINEAR MOTOR

If pneumatic tyres are acceptable, one may even simplify the whole question of points and crossings by regarding the railway proper to consist of a flat concrete bed, but with a central raised flange whose combined function is to guide the vehicles as a substitution for flanges on the wheels and to act as the "rotor" of a linear motor.

Under these circumstances, the stability and steering problems would be eliminated and it would be a feasible type of construction for a railway and probably not much more expensive than the present one.



Speculative design for linear motor express freight

When Joe's got his hands on a crafty 'cuppa' the last thought in his head is lubrication schedules. It's not that he means to cause a production hold-up, it's just that you can't trust a bloke like Joe the way you can Tecalemit Mechanical Lubrication Systems. They're sticklers for duty! Minute by minute *metered* shots of lubricant are fed to each and every bearing. Machines run more smoothly, have longer working life, give more reliable service. There are systems in the Tecalemit range to fit all machines and plant—new or existing—and to handle all lubricants—oil or grease. Get them to work for you—they never stop for tea!

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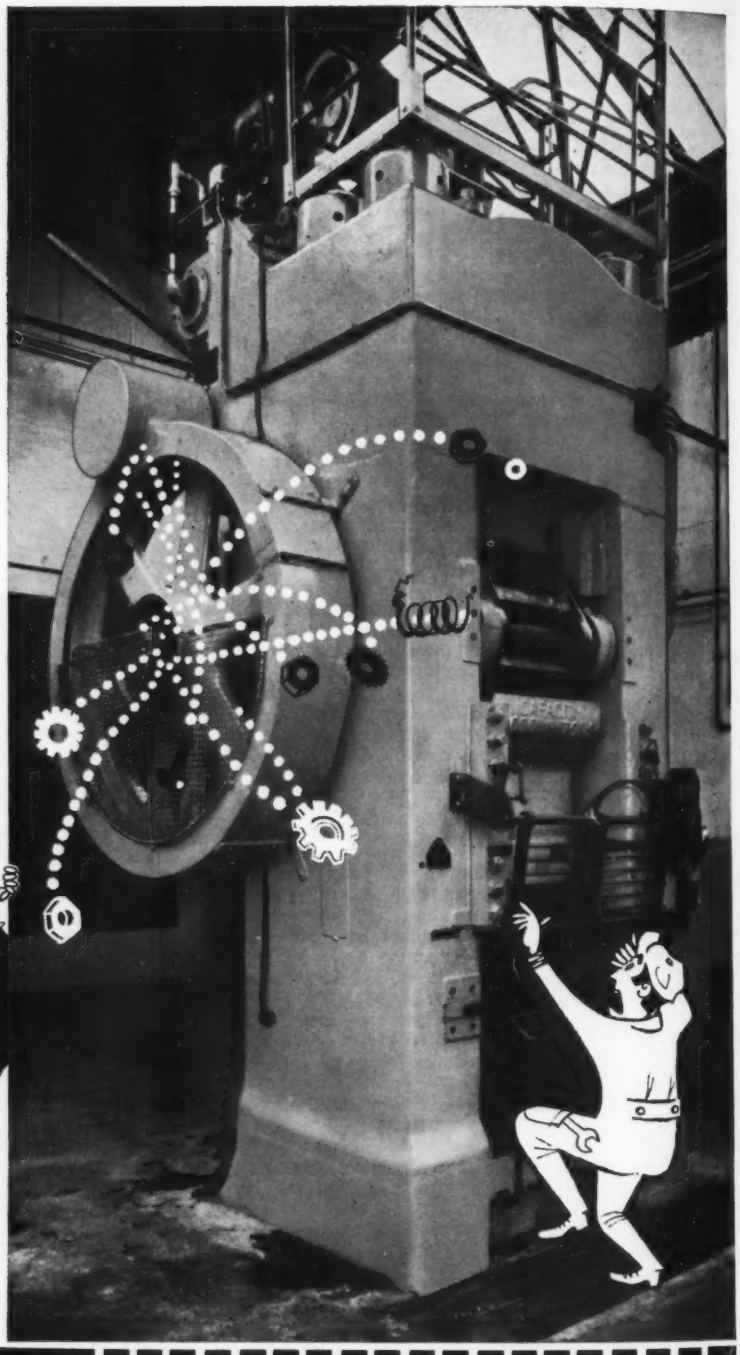

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Impact Testing of Plastics Water Pipes

Although plastics pipes for water supplies have been in use in Germany since before the last war, this experience is still regarded with some reserve by most public water undertakings who are able to draw on 250 years' familiarity with metal pipes. With such vast differences in the properties of the two materials, the British water supply industry is anxious to obtain as soon as possible optimum design criteria for long service of plastics pipes.

In iron and steel pipes, the greater part of the wall thickness is provided not to withstand stress but to compensate for the corrosion that can be expected during its lifetime, and its behaviour can be predicted very accurately. Plastics, of course, react to variations of stress and temperature in a more complicated way, and because their long term strength in this application is not easily predicted, the water industry is using fairly conservative ratings for plastics pipes.

Three kinds of pipes have British Standards either in use or in preparation—low density polythene, high density polythene and unplasticised polyvinyl chloride. Polythene would generally be used in diameters up to 2 in., but for larger diameters (where a more rigid structure is called for) unplasticised p.v.c. is used in diameters up to 6 in. Pipes of these materials have been installed in Britain in small quantities over the past few years.

A particularly important aspect of plastics pipes is their impact resistance; because they must withstand sudden shock loads in transit or when in the ground (from a pickaxe blow, for instance) a special study of this property is being made at the new research laboratories of the D.S.I.R. Water Research Association at Medmenham, near Marlow, Bucks. By means of a falling weight impact tester, the behaviour of unplasticised p.v.c. pipes has been studied at varying temperatures. The results have been shown that a reduction in temperature weakens the pipe to such an extent that while at 20 deg. C. the material is ductile enough to be punctured by the impact, at 0 deg. C. there is a greater probability of brittle fracture occurring, when the pipe will shatter like glass, and would thus cause more serious trouble to repair if the pipe was carrying water below ground level. The results of the association's work will contribute to the provision of a suitable impact test requirement in the new British Standard.

The association, which has more than 200 waterworks and local authorities in its membership, as well as a growing number of industrial companies, is concerned with the solution of such problems as rainfall and evaporation measurement, coagulation techniques to remove turbidity and colour from raw water, underground leakage detection, water sterilisation and algae control. One particularly promising line of work is that it intends to use a computer, shortly to be delivered, for determining the size of projected water mains and other distribution data.

THE JANUARY ISSUE

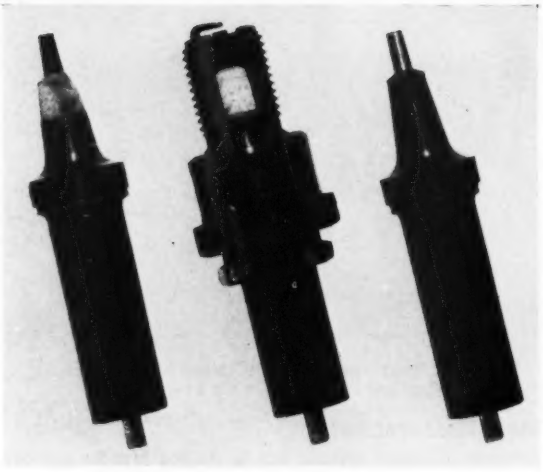
of *Engineering Materials and Design* will include the following main features:

Vacuum Pumps — Their Characteristics and Selection: Part 2
Concluding the survey of the technology, characteristics and accessories of modern vacuum pumps.

Asbestos in High Temperature Resisting Composite Materials: Part I
This first section deals principally with glass- and ceramic-fibre reinforcements.

The Sintering Process for Small Components
Each of the small mechanical and electrical parts considered in this article is regarded as being ideal for production by powder metallurgy techniques.

Design Approach to Ground Effect Machines
Dealing with some of the problems associated with various design configurations.



Experimental epoxy-resin sparking-plug insulator.

Plastics Sparking Plugs

The use of epoxy resins in a wide variety of industries is well known, and recently a sparking plug was made from a CIBA (A.R.L.) Ltd. epoxy moulding compound in order to show its good insulation.

The mean running temperature was between 450 and 500 deg. C. although the maximum temperature at flash point was between 3,000 and 3,500 deg. C. The head pressure of the 1,500-cc. engine in which the plug was fitted was between 700-800 p.s.i., and the voltage across the spark gap was 15,000 to 18,000. Naturally, under these severe working conditions, it may be expected that the life of the plug will be short (the effect of only a few hours' use is shown in the left-hand illustration).

Admiralty Reinforced-plastics Boats

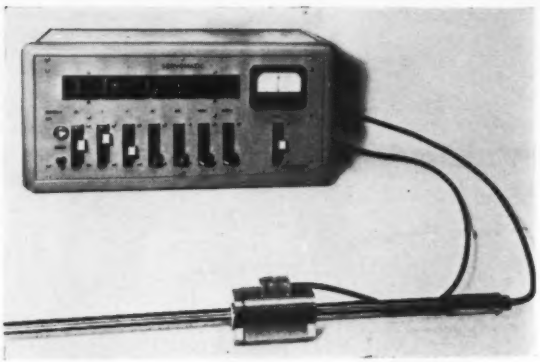
For the past ten years the Royal Navy has been evaluating the use of glass reinforced plastics for boats under 30 ft. in length. As a result this type of construction is now contemplated where numbers will justify the mould cost, while the design of larger boats in glass fibre reinforced plastics is under consideration.

Experience has been gained with various resins and reinforced materials on composite, sandwich, round bilge and hard chine designs. Exhaustive testing of boats using both cold-set and hot-set construction has been carried out all over the world in H.M. ships.

One of the great advantages and financial savings accruing from the use of these boats in the Navy is the resultant release of manpower which would otherwise be engaged in H.M. Dockyards on the maintenance necessary with traditionally constructed boats. A further saving is made by abolishing the present need for sheathing wooden boats used in tropical waters to combat worm and microbe attacks. Apart from the obvious savings of men and money on maintenance, the adoption of reinforced plastics in small boat construction in the Navy means resultant increases in the speed and ease with which boats can be repaired.

One of the main disadvantages was the decline in appearance of the plastics boats after considerable use in Fleet service, but recent paint tests carried out by Admiralty research establishments have established that this can be overcome by traditional brush painting.

Experience has also been gained by Admiralty with the use of plastics sandwich construction on a fast 16-ft. motor boat. The hull consisted of expanded p.v.c., $\frac{1}{4}$ in. thick, sandwiched between laminations of glass reinforced plastics. This provided inherent buoyancy, a clean internal surface and a degree of rigidity sufficient to allow frames to be dispensed with. It was considered that the rigidity of the shell and elimination of frames given by the sandwich method of construction was a sound technique for small boats.



Servomatic linear measurement indicator, with interpolating head and shaft shown in the foreground.

Linear Measurement

Length measuring systems can be divided broadly into two types—digital or incremental, and analogue or proportional.

A scale calibrated in discrete steps, a pile of slip gauges, or a diffraction grating, are of the incremental type; while proportional systems are represented by the screw thread and nut, or the wound helix or similar patterns. The advantage of the incremental system is the high accuracy of successive steps, but each step must be counted and stored, and the loss of one is a continuous error. The analogue method has one unique indication of position, but it is difficult to manufacture the measuring elements to the very high precision required.

The Servomatic system developed by Reilly Engineering Ltd., has the advantage of both systems in that it gives an analogue representation of position using an incrementally constructed measuring element. The standard form of measuring element consists of a series of accurately made cylinders insulated from each other and cemented on a tie bar.

A cylindrical interpolating head of considerably larger diameter than the stators of the measuring element is held within a housing on insulating guide bushes so that it can slide concentrically over the shaft. The measurement is made by the relative movement of the housing to the shaft, and the point of reference is the geometrical centre of the housing. Two leads connect the transducer to the indicator unit, one from the shaft and one from the interpolator.

These are connected to a precise voltage dividing transformer. The voltage between each segment is equal, and a very small pick-off electrode, close to but not touching the row of segments so that it has a capacity to them, will increase in potential in a series of steps as it is moved along. If the pick-up electrode is made the same length as the segments it will act as a differential condenser and interpolate continuously between the voltage on the individual segments.

To avoid making very accurate measurement of voltage, the circuit is constructed as a bridge so that the position of the pick-up relative to the row of segments is compared with the position of a tap on a transformer.

Transducers are normally made from steel, but can be in any material—brass, ceramic, or Invar, to suit the application.

Atomic Battery for Space Vehicles

The first atomic battery to be used in a space satellite has continued to operate successfully after several months in orbit.

The experimental nuclear device is generating electricity for two of the four navigational transmitters of the Transit IV-A satellite launched in June at Cape Canaveral; the satellite is circling the earth every 94 min. in a near-polar orbit.

The device is a tiny, lightweight thermoelectric generator, fueled with plutonium-238 and generating 2.7 watts of electrical power. Solar cells are providing power for the other two navigational transmitters.

Developed for the Atomic Energy Commission by the nuclear division of the Martin Co., Baltimore, the generator is approximately 5 in. dia. and 5½ in. high, and weighs about 4.6 lb.

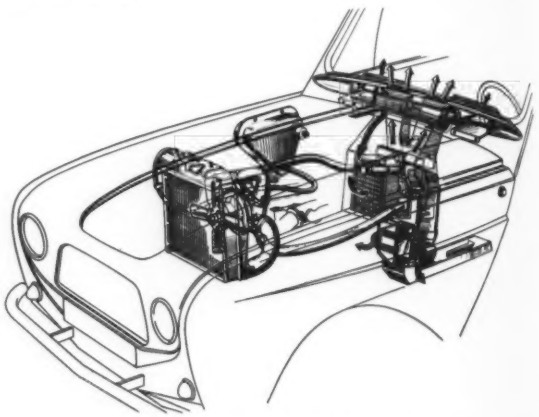
Plutonium-238 fuel is contained in a capsule in the centre of the sphere. Because the plutonium has a half life of about ninety years (i.e. its radioactivity, and therefore its heat generating capability, will drop by only 50% during that period), the generator can power a space transmitter for decades.

In the generator, the spontaneous decay of the plutonium-238 generates heat in itself and is transferred to the containment block surrounding it; thermocouples convert this heat directly into useful electrical energy.

New Renault Car

The new 747-cc. front-wheel-drive Renault car is a durable, ubiquitous transport, having ultra-low running costs. It incorporates several features of particular technical interest.

The elimination of greasing has been achieved in four ways. Firstly, by normal lubricant held in a sealed space; this may take the form of sealed rubber sleeves around complete units such as the universal joints. The second way is by normal lubricant held in porous metal; sintered metal bushes are used, e.g. for certain suspension and steering joints. The third method is by using solid lubricant. In this case, the lubricant is a solid material with a low coefficient of friction which provides dry bearings used, for example, in steering linkages (bearings in graphited aluminium) and gearchange linkages. Finally, rubbing can be replaced by elastic deformation. This method is only suitable where movement is limited, and is used on the suspension arms at front and rear, a rubber member taking the form of a tube.



Sealed cooling system of the new Renault.

The sealed cooling system has been achieved by the use of a coolant solution (water, glycol and inhibitors), which has a high boiling point (110 deg. C. at atmospheric pressure) and a freezing point below − 40 deg. C. The cooling system of the car is completely filled with liquid, and is connected with a small-bore tubing with a compensatory system for expansion and contraction, this consisting of a separate reservoir containing a small amount of liquid which covers the outlet of the tube from the main system. According to how much work is being done by the engine, the ambient temperature, and variations in atmospheric pressure, so there is a movement of fluid in or out of the compensating tank—thus the main system always remains full. This results in pressure variations throughout the system, as there is no escape to atmosphere. The amplitude of pressure variations is, however, limited by a two-way valve at the top of the compensatory reservoir.

E. M. & D. CONFERENCE PAPERS

Sets of each day's papers given at the E. M. & D. Conference will be available from Heywood & Co. Ltd., Drury House, Russell Street, Drury Lane, W.C.2. Prices will be announced later.

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DESIGN WHO'S RESPONSIBILITY?

WHEN opening the recent 1961 International Design Congress, Lord John Hope, the Minister of Works, commented "British design at its best compares with any for robustness, but too often lacks attention to the final appearance of the product and to details of convenience in use". There are many who will disagree with his reference to the "robustness of British goods"; nevertheless from the design aspect his reference to appearance and convenience should be taken as a timely warning.

"The first step towards a design policy is to be aware that a problem exists"—it might appear that in saying this at the Congress the chairman of the Council of Industrial Design, Sir Duncan Oppenheim, was stating the obvious, but in surveying some British goods one is left with the impression that, like Topsy, they just grew. The chairman went on to express the opinion that design is for the professional who is an artist, and not for the amateur or the professional who is not an artist.

Every successful designer must of course be an artist in his own profession, but he does not necessarily have to possess an artistic flair for developing products with eye-appeal. This is the true artist's province, and should remain distinct from the designer's. It is more than likely that the inconvenience of products mentioned by Lord John Hope has resulted from the touch of the artist rather than the engineer.

A. H. Milward, chief executive of B.E.A., believed that a successful design policy must be inherently the work of one man—good designs did not come out of a committee which had to compromise at every point if the views of all the members of the committee were to be taken into account.

In designing there are three basic stages —the concept, the process and the result. Into these must be underwritten the need for the product. As James D. Bowles of Ampex Computer Products has said, all too often modern designs are concerned with the spirit of uniqueness rather than meeting the need for functional excellence.

The concept consists of the aesthetic and the functional, which must ultimately be so integrated that one is unaware of either. Nevertheless in the beginning, unless the designer is one of those rare beings whose faculties can command and control both the aesthetic and the functional, a design must necessarily be a co-operative effort.

Professor Misha Black, Professor of Industrial Design (Engineering) at the Royal College of Arts, observed that clients always got the design they deserved, the difficulty being that the client rarely knew what he wanted — if the designer took his job seriously he concerned himself with what the client needed. Professor Black went on to suggest that each project should be accompanied by the establishment of a design or steering committee, which should in effect be the critics of a specific design proposal, but never the body which designed.

This is sound common-sense, since it can be practically applied to engineering whatever the size of company. Two people who must be represented on such a committee are the man who has the responsibility of producing it, and the man who has the responsibility of selling it. It is surely at the stage when the design is frozen and the processing starts that the one-man policy should commence.

The third stage is the result, and it is by this that the company will be judged. The product must work efficiently, and must be pleasing to look at. Can one man produce this result on his own?

It is quite evident from the remarks made by the various speakers at the International Design Congress that a considerable divergence exists between the designer and the artist on what is meant by a design policy. Compromise there must be, however, and the ideas of Professor Black are to be applauded.

It is time the artist descended from the clouds and the engineer arose from the earth to understand and appreciate each other's difficulties, and to integrate their skill in a product which will keep Britain in the lead. In this, the Council of Industrial Design can play a vital part—let it not become just a symbol of status.

The Editor

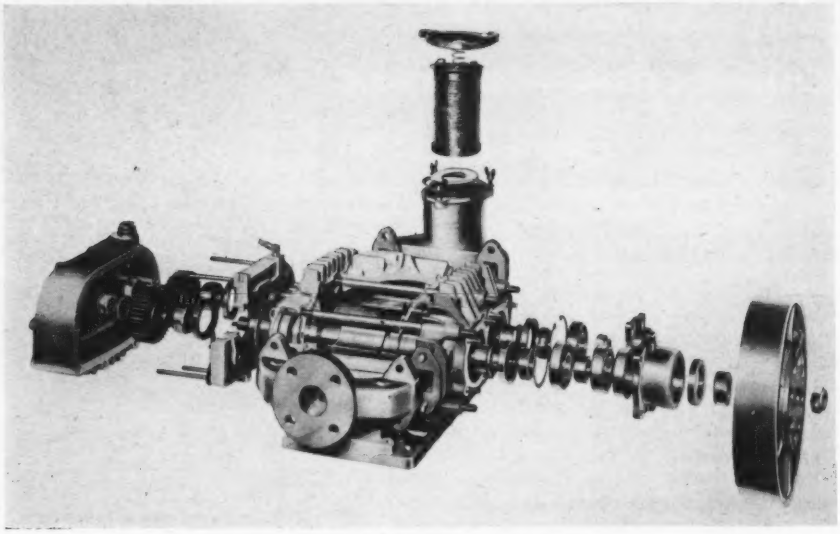


Fig. 1. Exploded view of a Northey exhauster.

VACUUM PUMPS — THEIR CHARACTERISTICS AND SELECTION Part 1

by M. E. BOSTON, M.A.*

The technology of vacuum engineering and scope of vacuum plant continues to widen year by year. This article is a survey of the principles and accessories of modern vacuum pumps

EVERY engineer is now and again confronted with problems in a new field and often finds it difficult to obtain an up-to-date overall picture. This survey article does not pretend to be a complete *vade mecum* on the subject, but it will help the designer to build up complete pumping systems.

Typical Applications

Vacuum is often discounted as an expensive and mainly unnecessary tool. But the part that vacuum plays in industries of every sort is not generally realised, nor is the extent to which it affects our daily lives. Nowadays there must be few industries not using it in some essential way.

For instance, all the sugar eaten is crystallised under vacuum, as the penultimate stage in a process initiated before the turn of the century for the production of raw sugar. Thousands of tons of water are first evaporated under vacuum, then washed away in vacuum condensers. The fact that the annual production of sugar runs into millions of tons is sufficient proof of the economic importance of this vacuum process.

On a very different scale, but no less vital, is the production of radio receiving and transmitting valves. Output amounts to many millions of units each year, and the degree of vacuum reliably attained—approximately 10^{-12} of an atmosphere—indicates the degree to which the production techniques have been perfected.

The designer may encounter other processes or uses. These may be to simulate conditions in outer space; to generate air flow in a low density wind-tunnel; to melt, heat-treat, or degass metals under vacuum; to dry, distill or process any of a wide variety of heat-sensitive chemicals or foods; to consolidate concrete; or to fumigate merchandise. Vacuum pumps of some sort will be needed, and the designer will certainly need some acquaintance with vacuum principles.

The Vacuum Spectrum

There are some $2{\cdot}7\times10^{19}$ molecules per cc. at standard temperature and pressure, but in outer space only some 3 or 4 per cc. (10^{-16} Torr). Vacuum is concerned with the whole of this vast realm, though man has so far reached only about 10^{-13}T. (3,000 to 4,000 molecules per cc.). It is divided into the following regions: low, 760-25T.; medium, 25-10^{-3}T.—or alternatively: rough, 760-1T.; fine, 1-10^{-3}T.; high, 10^{-3}-10^{-6}T.; very high, 10^{-6}-10^{-9}T.; ultra high, 10^{-9} onwards.

There are many confusing terms used in vacuum engineering nowadays, so this article uses only the international term Torr (T.) corresponding to an absolute pressure of 1mm. of mercury. The designer must constantly be on his guard with indiscriminately used units (p.s.i., inches of water, microns, feet of water, bars, etc.) and the terms

*Director, Torvac Ltd., Histon, Cambridge.

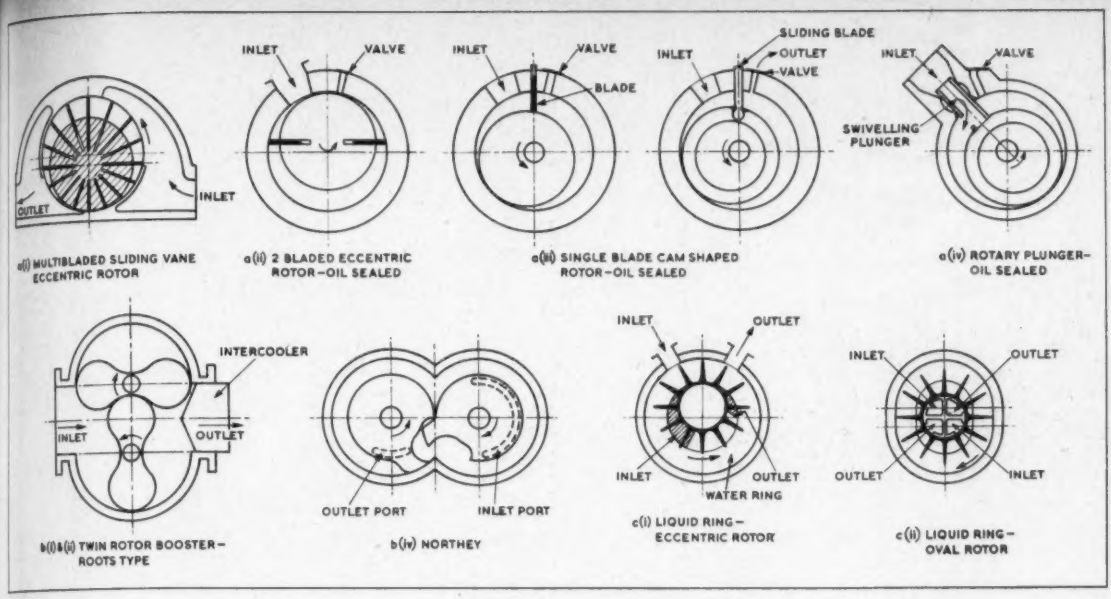


Fig. 2. Operating principles of Group 1 vacuum pumps (see Table 1).

"gauge" and "absolute"—gauge being relative to atmospheric pressure.

Properties of Gases at Reduced Pressures

Gases obey the classical gas laws even down to very much below atmospheric pressure. The total pressure may be made up of gases with partial pressures differing in proportions from atmospheric, and some part of it may come from vapour not normally significant at atmospheric pressures. This latter part arises from the vapour pressure of liquids and solids, which is often present only in traces on internal surfaces in vacuum systems, and the effect becomes of greater and even overriding importance as the vacuum improves or the surface temperature rises.

Another factor of overriding significance at reduced pressures is adsorption. Normally, at atmospheric pressure, surfaces are coated with at least a monomolecular layer amounting to some 10^{15} molecules per sq. cm. This layer is in equilibrium, and is dependent both on temperature and on adjacent gas density: as temperature is raised and vacuum improves, the layer gradually thins out, but its complete removal is a slow process. So, in the high vacuum region onwards, the molecules evolved from surfaces—even clean surfaces — are orders of magnitude more numerous than the residual gaseous molecules. If the surfaces are not chemically clean, or if gases are absorbed below the surface, gas evolution is still larger.

The kinetic theory conveniently explains the properties of gases at reduced pressures, just as at atmospheric pressure. It also explains the effects connected with "mean free path" (m.f.p.), i.e. the statistical mean distance that molecules travel without colliding with each other. It is a property which is proportional to the inverse of absolute pressure, and to absolute temperature. (At 10^{-3}T. and 15 deg. C. the mean free path of air is 4·86 cm.—that of hydrogen is 8·97 cm.).

Gas flow is influenced by mean free path. When it is about one-hundredth of the typical dimension of the vacuum system, gases begin to flow in a way no longer characteristic of the streamline viscous flow at atmospheric pressure, and molecular flow begins to set in. This new type of flow predominates when the m.f.p. is about one-third of the typical dimension. It is best explained as follows. As the mean free path increases, the probability

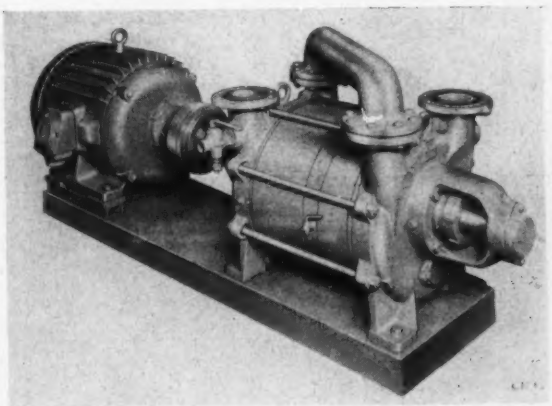
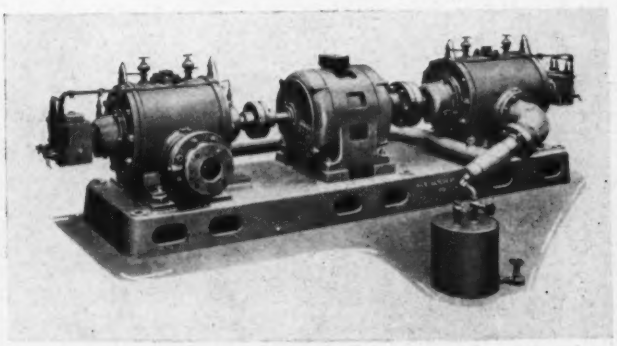


Fig. 3. Sihi liquid ring pump (Hick Hargreaves & Co. Ltd.).

Fig. 4. Two-stage multibladed sliding-vane pumping set with interstage drain—capacity 400 c.f.m., ultimate vacuum 1·5. (Hick Hargreaves & Co. Ltd.).



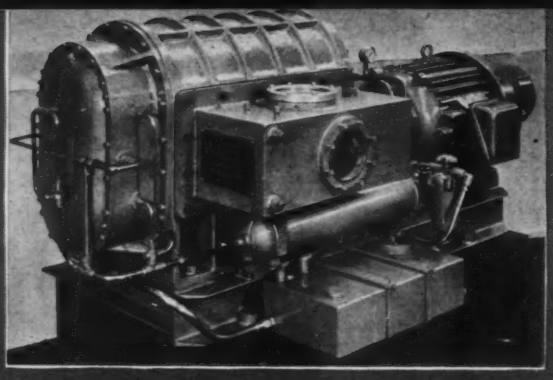


Fig. 5. Single-stage Roots-type mechanical booster pump fitted with inter-cooler and oil-cooled rotors —capacity 5,000 c.f.m. with 10:1 compression ratio (Geo. Waller & Co. Ltd., and Torvac Ltd.).

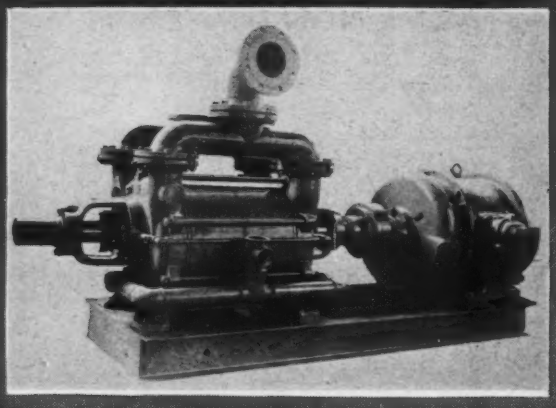
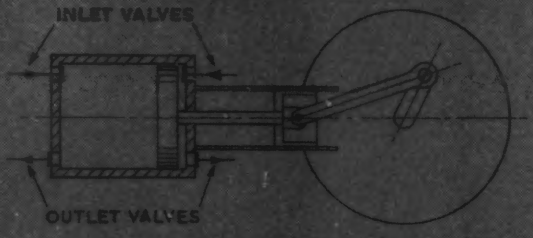
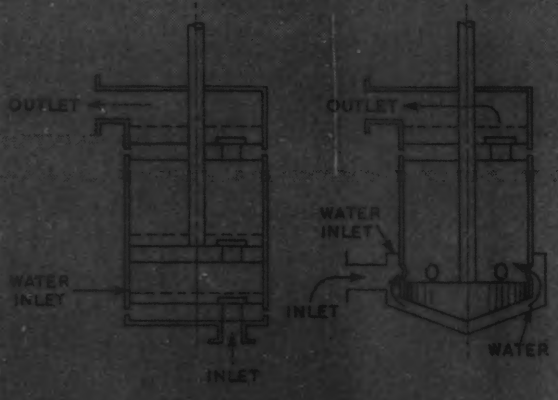


Fig. 6. Two-stage water-ring pumping set with a capacity of over 500 c.f.m. and an ultimate vacuum of 25 T (Hick Hargreaves & Co. Ltd.).

Fig. 7. Operating principles of Group 2 vacuum pumps.



a(i) DRY RECIPROCATING DOUBLE-ACTING HORIZONTAL CROSSHEAD



a(ii) WET RECIPROCATING SINGLE-ACTING VERTICAL

that a molecule will find its way along a pipe without colliding with the boundary wall or with another molecule steadily diminishes. If it collides with a boundary wall it will be reflected diffusely, and will lose its way with little likelihood of colliding with another molecule having a velocity component in the right direction. This underlines the need for large and unobstructed pumping lines in medium- and high-vacuum systems.

The foregoing properties will remind the designer of some of the important factors influencing his choice of pumps.

VACUUM PUMPS

Vacuum pumps can be divided conveniently into groups according to construction. The more familiar designs intended to compress gases above atmospheric pressure can generally be used also as vacuum pumps with little modification, and will reach between 1 and 100 T. Strictly speaking, centrifugal and axial fans should be included—they produce a vacuum of sorts (some 725 T.), but as they are used primarily to propel rather than compress, they will be left out.

In the medium to ultra-high vacuum regions there is a broad range of pumps which do not compress the gas and remove it, but instead capture and retain it within the system in an inactive form.

The many groups of pumps are set out in Table 1, and the operating principle of most of them is illustrated in the accompanying diagrams. The notes which follow mention briefly some of their characteristics, advantages and disadvantages, but more detailed information can be obtained from makers' catalogues. Groups 1, 2, 4 and 8 can be used on their own as single-stage machines, but most can be arranged two-stage, with or without others in the remaining groups.

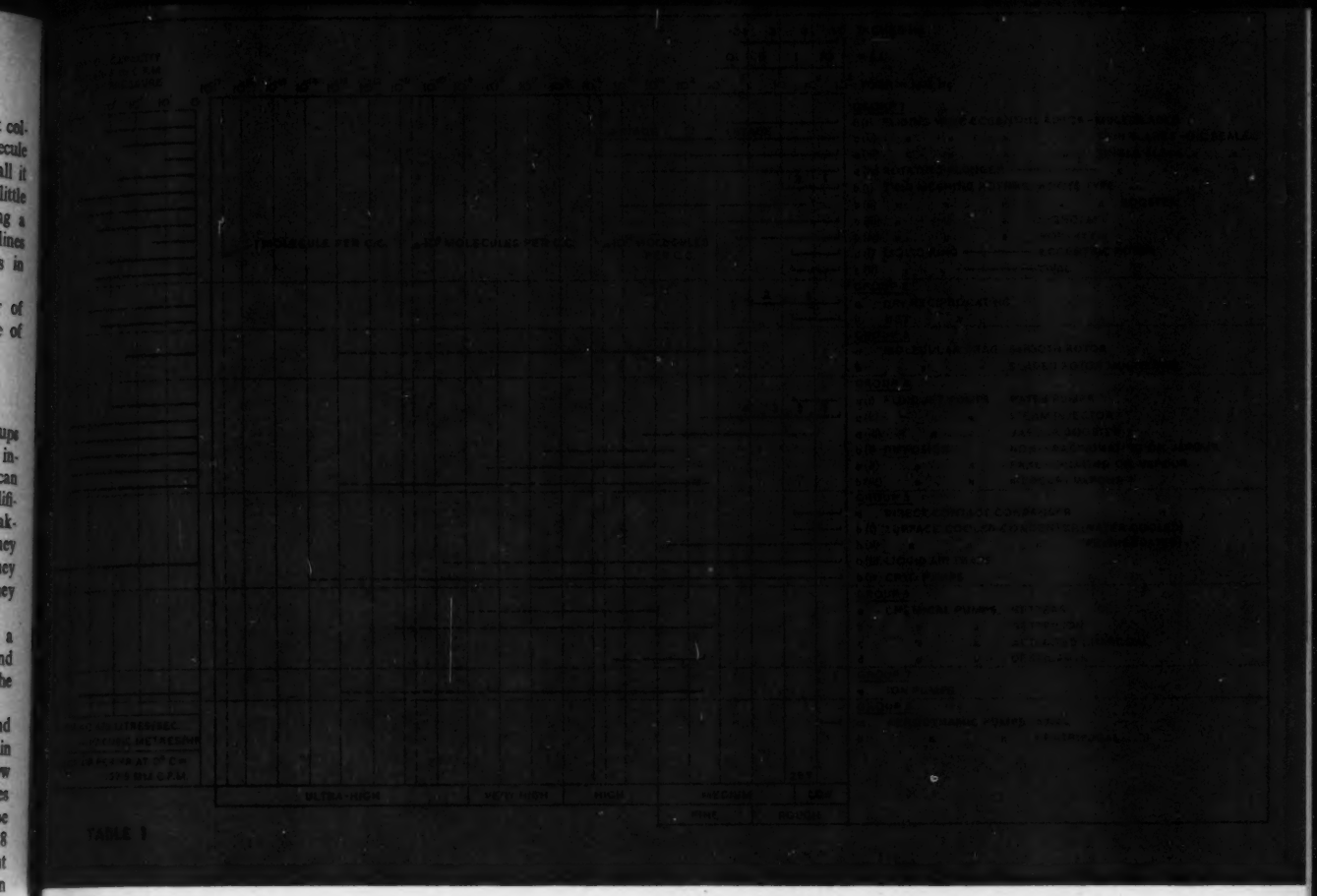
No one pump will work over more than a limited range, and a compression ratio of more than 100 is unusual in the low and medium range. Where a large gas flow is being handled, ratios less than this are more usual.

Sliding-vane Eccentric-rotor Machines (Group 1a)

This group embraces both the important oil-sealed rotary and the multi-bladed high-speed machines. Oil-sealed pumps have the advantage that high compression ratios can be obtained (10,000 and even 100,000 to 1), and they are used as much as "backing" pumps for the pumps in groups 5, 6 and 7 as on their own. Most of the many forms have a circular or near-circular stator, and either an eccentrically-placed rotor holding one or more sliding vanes, or a cam-shaped rotor without blades sweeping the stator and sealed by blades sliding in the stator. One important form is the rotary plunger machine shown in Fig. 2., developed to reduce wear. The great variety of designs results from attempts to reduce wear and to improve both cooling and sealing. Some machines have balanced rotors, others are inherently unbalanced. They can be used as single or two-stage units. The multi-bladed high-speed types are available in larger sizes, and as they are not oil sealed, but only lubricated, the compression ratios reached are lower. Being in balance they can run faster, and are capable of larger displacements.

Twin-meshing Rotor Machines (Group 1b)

In this group all the machines have two meshing rotors running parallel to each other, driven in synchronism by timing gears, so that they mesh with small clearances at all times. The meshing lobes may be straight or helical, and there may be two or more to each rotor. The rotors



run at high speed, and there are no out-of-balance forces. If clearances could be eliminated a high compression ratio would be obtained, but in practice leakage ("slip") takes place and neither the theoretical displacement nor a very high compression ratio is achieved.

Where there are no valves or ports, compression takes place when the pocket of gas at lower pressure is exposed by the lobe at the outlet: gas rushes in and compresses it. Where there are ports the gas is compressed during rotation, and is expelled at higher pressures as the port becomes exposed. This takes place ideally without shock, but in practice with some under- or over-compression. The Roots types have no ports, so there are four pulsations for each revolution with considerable gas turbulence and temperature rise.

The great advantage is that as the rotors do not touch they can run dry: there are no sliding parts exposed to vacuum, and so no lubricant is needed. Furthermore, as the rotors are in balance they can rotate at high speeds under reduced pressures to obtain a large specific capacity. A potential disadvantage is their inability to handle large quantities of dust or very wet gases. These machines run as single or multi-stage units, and, as boosters, Roots type pumps have become important in recent years.

Liquid Ring Pumps (Group 1c)

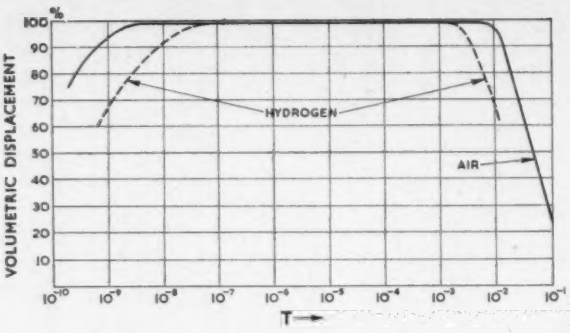
This group uses a ring of liquid (generally water) to seal a space between the blades of an impeller and the wall of the stator. Due to centrifugal force the water forms a rotating ring the depth of which varies according to the amount present. Some machines have a bladed impeller placed eccentrically in a circular stator, producing one cycle for each revolution—thus is a side load on the impeller. Others have a similar impeller placed at the centre of an oval stator producing two cycles per revolution, and with a symmetrical loading on the impeller. As a group they have the advantage that they will condense water vapour and remove other condensable process gases and contaminants. Sufficient water must be run to waste to keep the machine cool, as water vapour limits the ultimate vacuum.

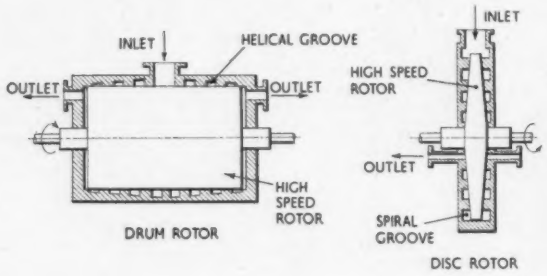
They are used as single or two-stage units. There is always a risk that if the machine slows down, or if the water supply fails, the water ring can collapse and cause a suck back, but precautions can be taken against this.

Reciprocating Machines (Groups 2a and b)

The operating principle of these machines is well known; they were the earliest to be used for obtaining vacuum. They are today available arranged horizontally or vertically with single cylinders or in groups of two or three, with or without intercooling. The vertical designs are capable of the larger displacements. There are two basic types: "dry", using only small quantities of oil; and "wet", flooded with water to seal, cool and lubricate. Dry reciprocating pumps are frequently water jacketed, and can be double acting with corresponding double ports and valves. These valves are either positively controlled or spring loaded, but the operating mechanism is not exposed to vacuum. Rubbing speeds are low and the cylinder needs little lubrication, so the oil can be run to waste to avoid contamination. Small quantities of liquid will pass through the pumps, but there is danger of severe damage if it accumulates, unless a special relief valve is incorporated in the end of the cylinder wall.

Wet reciprocating pumps attain higher compression ratios, as the water both seals the piston and partly fills the clearance volume. Valves and ports are arranged to





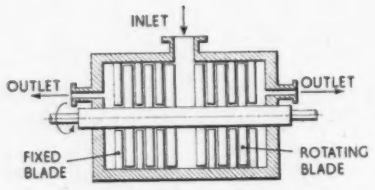
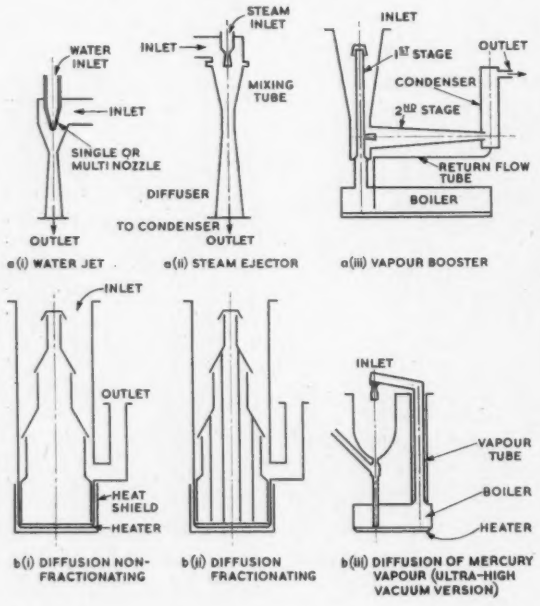


Fig. 8. Operating principles of Group 3 vacuum pumps, with graph showing performance.

Fig. 9. Operating principles of Group 4 vacuum pumps.



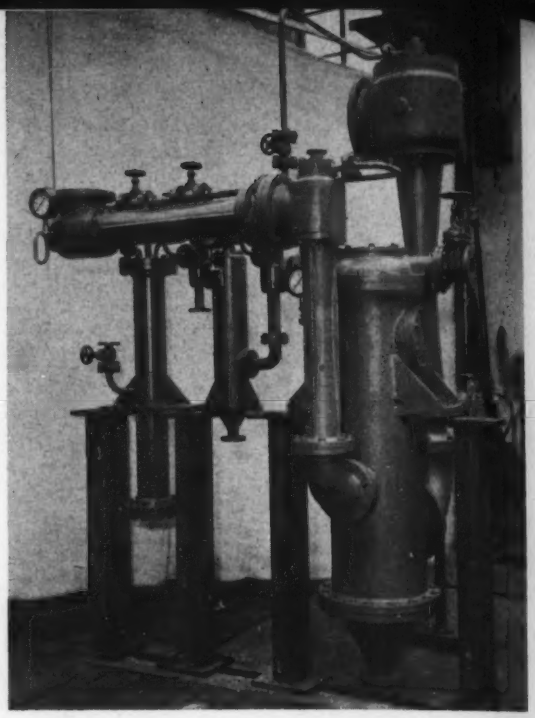


Fig. 10. Steam ejector pumping set, dual capacity. This can be arranged as a four-stage unit with a capacity of 600 c.f.m. at 0·5 T, or 4,200 c.f.m. at 30 T. With four stages in use the first stage is an augmentor (with horizontal axis). The second stage delivers to a direct-contact condenser, and is followed by two further stages of smaller ejectors and direct-contact condensers. With three stages in use the two stages at the front are replaced by the larger one at the back (Hick Hargreaves & Co. Ltd.).

Fig. 11. Single-stage ultra-high-vacuum 1½-in. mercury diffusion pump—capacity 40 c.f.m., ultimate vacuum 10^{-10} T. (Services Electronic Research Laboratory, Baldock, and Torvac Ltd.).

reduce or eliminate the pressure drop associated with spring-loaded valves. They will handle large quantities of liquids and contaminants. But as with all water-sealed pumps, the ultimate vacuum is dependent on water temperature. As they are reciprocating, they are essentially slow moving, and are large for their capacity, but being heavily built are dependable.

Molecular Drag Pumps (Groups 3a and b)

Centrifugal and axial aerodynamic (turbo) compressors quickly become ineffective as inlet pressure is lowered, and are of little use as vacuum pumps. However, if extensively modified and backed by another stage to a vacuum of about 10^{-2}T., and speeded up, they can perform in this region on a different principle. Molecules striking the fast-moving impeller acquire some momentum, and tend to move in the direction of rotation. The effect can be put to practical use in specialised machines rotating at upwards of 6,000 r.p.m., using either a smooth disc-shaped or drum-shaped rotor running in a spirally-grooved stator, or a multistage machine with rows of blades alternately fixed and rotating. All have the advantage of running dry, and when backed to 10^{-2}T. show uniform capacity over a wide range (i.e. from 10^{-2} to 10^{-9}T.). Unlike other dry-running positive-displacement rotary machines (Roots type) the rotors are not alternately exposed to inlet and outlet pressures, so surface absorption does not introduce a reverse pumping action and they are inherently capable of higher degrees of vacuum.

Fluid Jet Pumps (Groups 4a and b)

This most important but perhaps less familiar group can be divided into two halves. All work on much the same principle, but are entirely different to the preceding groups of mechanical pumps; they use a fluid jet (liquid or vapour) to achieve compression.

Group 4a includes water, steam and mercury ejectors and vapour booster pumps. These are used from atmospheric into the medium vacuum region. Liquid or vapour emerges from a nozzle as a high-velocity jet into a mixing section. Here it meets the gas, entrains it by turbulent mixing, and imparts to it some of its momentum. The mixture then passes into a diffuser section where it slows down and is compressed. If the motive fluid is a liquid it separates in the diffuser, but if a vapour it is separated from the gas subsequently in a condenser; the gas can then be led to a second pumping stage. In some cases the whole of the mixture is fed to a second stage for further compression before any motive vapour is condensed out. This may be essential if steam ejectors operate in the medium vacuum region where the condensation temperature is near the freezing point of ice. Steam and water ejectors are well able to handle dust.

In group 4b are the diffusion pumps, which use special oils or mercury as the motive vapour. These pumps develop only a small pressure difference, and their action differs slightly from ejectors. Mixing of the gas with the motive fluid is better described as "diffusion" rather than "entrainment": gas molecules diffuse into the vapour jet, where they acquire some momentum and move with the motive vapour. The vapour is then condensed as before.

Diffusion introduces a further effect: just as the gas molecules diffuse inwards into the vapour jet, so also the vapour jet diffuses outwards and some vapour escapes by "backstreaming" into the vacuum system. Attempts are therefore made to reduce backstreaming to a minimum, and cooled baffles or traps are almost invariably fitted above diffusion pumps.

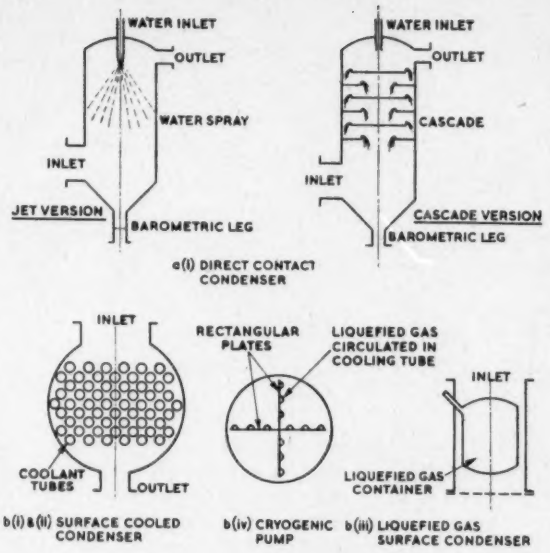


Fig. 12. Operating principles of Group 5 vacuum pumps.

Condensation Pumps (Groups 5a and b)

Direct contact and surface condensers are used after the diffuser section in ejector systems, but condensation pumps have a much wider application and are of greatest value where condensable vapour of any sort (generally water vapour) predominates. Their use in the sugar industry has already been mentioned, and direct contact condensers are referred to there. Cool water is sprayed or cascaded over the vapour to be condensed, or if it is propelled at high velocity as a jet it can be made to perform a second function as a jet pump for non-condensable gases as well. The ultimate vacuum is limited by the water temperature, but direct contact condensers are simple and will deal with dust and contaminants. The condensed mixture is drawn out by an extractor pump, or collects in a barometric leg (a tube supporting a column of water up to 34 ft. high).

Surface cooled condensers are generally of the shell and tube type, and are more expensive and more bulky. They are used when water should not contact the vapour being condensed. To be fully effective, flow of vapour in the condensers must be turbulent, and the residual gas pressure must be one-tenth or less of that of the vapour. The coolant may be a refrigerant, chilled water, or water at ambient temperature.

If the surface condenser is below 0 deg. C., ice will condense from any water vapour present, and it will build up on the surface, eventually choking the system. Rotary condensers with scraper blades continually removing solid build-up are available for such applications. The minimum practicable temperature using circulated refrigerants is -60 to -70 deg. C. (corresponding to water vapour pressure of 8×10^{-3} to 2×10^{-3}T.), but the residual gas pressure must be correspondingly lower.

At temperatures lower than this liquefied gases can be used, and even more complete removal of condensable vapours is possible, but handling liquefied gases on a large scale presents problems of its own. Circulating liquid hydrogen or helium allows even more complete pumping. At liquid hydrogen temperatures nitrogen and most other permanent gases are solid, and a technique has been evolved from this for large scale pumping of pure nitrogen in low-density wind tunnels.

This article will be concluded next month, and will contain graphical information relating to all groups of pumps mentioned.

THERMOPLASTICS IN DESIGN

The author explains just how far it is possible to use standard methods of design when dealing with thermoplastics, and indicates some of the additional aspects which have to be considered

by P. V. VINCENT, M.A.*

PRODUCERS of plastics are frequently asked by engineers for data to assist them in design. The request is usually for the type of constant that has been found useful with metals, since most engineering experience has been gained in that field. When designing with thermoplastics, it is often possible to use the principles and methods that have been found satisfactory with metals, but, as always, it is desirable to have some familiarity with the special properties of the material to be used. This article is an attempt to explain how far it is possible to use standard methods and to indicate some of the additional points which may have to be considered. It deals in turn with the various material properties which might be asked for in a typical enquiry. First, deformation properties, such as Young's modulus and Poisson's ratio; then strength in tension, flexure, compression, shear and impact.

Young's Modulus and Poisson's Ratio

A request for the values of these elastic constants implies an intention to use formulae which have been calculated by assuming Hooke's law; for example, the comprehensive and useful collection tabulated by Roark[1]. It is clearly most desirable to be able to take advantage of the efforts of those who have derived such formulae, and it *is* possible with thermoplastics, with three important provisos.

The Effect of Strain

The strain at yield for ductile thermoplastics may be very large in comparison, with that for metals. Table 1 gives some results, determined in tension at 20 deg. C.

Table 1. Strain at yield of various ductile thermoplastics (at 20°C.)

Material†	Tensile Yield Strain (%)
Welvic R7/80	2·9
Darvic 110	3·2
Propathene GWE-01	7·5
Alkathene XDK-10	12·6
Fluon G1	—25·0
Mild steel	0·1

Although it is necessary for some purposes to subject materials to any strains up to the yield point, it is not possible to assume that Hooke's law is true over the whole range. Indeed there are deviations at very low strains. Sandiford[2], for example, has shown that Hooke's law is not true for polythene even at strains as low as 0·2%. For the purposes of engineering design, however, some deviations can be tolerated. The elastic constants, determined at very low strains, may be used for design in the usual way, up to a certain limiting strain which is analogous to the elastic limit in metals. It is important to note that this "elastic limit" is not a constant of the material, but depends on the accuracy required in any particular application. If the accuracy can be specified, the strain can be found at which the divergence becomes too large—this strain is treated as the elastic limit.

If it is necessary to design accurately for strains above the "elastic limit", this can be done, but the procedure is more complicated. The relationship between stress and strain must be determined, up to the yield point, and the required formulae must be derived from first principles, without the assumption that stress is proportional to strain.

Fig. 1 illustrates the application of these two design methods to a Propathene specimen tested in a three-point loading bend test. The line *A* was calculated from the Young's modulus at low strain, assuming Hooke's law. The curve *B* was found by experiment. The points on curve *B* were calculated from the compression stress-strain curve from first principles without assuming Hooke's law. It can be seen that the elastic calculation is satisfactory up to the region of 1 or 2% strain, but that thereafter the deviations become large. It can also be seen that the more detailed method for high strains, though tedious, is reasonably accurate.

The Effect of Time

Just as for metals at high temperatures, it cannot be assumed that the elastic constants of thermoplastics, even at normal ambient temperatures, are independent of time. They are found to vary according to the time, rate of straining or vibration frequency at which they are measured. Fig. 2 shows the strains of some thermoplastics determined under constant tensile load over a range of times at 20 deg. C. (These unpublished results were obtained by S. Turner in the I.C.I. laboratories.) An apparent modulus can be calculated by dividing the stress by the strain at any time. It is

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†A description of the materials mentioned in the Tables, Figs. and text will be found in the Appendix on page 821.

evident that the elastic "constants" used for design must be relevant to the time that the article is expected to be under load. For very long times, it is necessary to adopt some extrapolation technique.

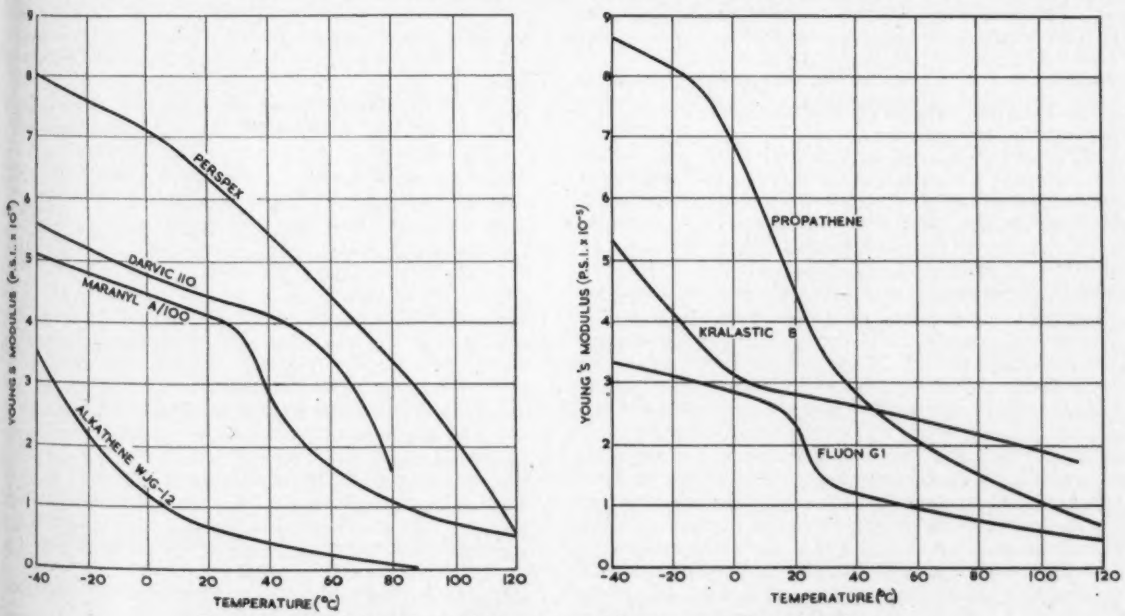
The Effect of Temperature

The elastic constants of thermoplastics are much more dependent on temperature than those of metals. Consequently it is most important to use the values measured at the proposed service temperature. Figs. 3(a) and 3(b) show the Young's modulus of some thermoplastics determined at a frequency of about 100 c/s over a range of temperature. (These unpublished results were obtained by D. J. H. Sandiford and Miss D. A. Thomas in the I.C.I. laboratories.)

Even if the strains are below the "elastic limit", in some systems the deformations may be too large for the simplest formulae to be sufficiently accurate. This is more likely to occur with plastics than with metals, owing to their lower moduli and higher strains. For example, in the bending of flat plates, the deflection may be more than half the thickness, and there may be large errors unless diaphragm stresses are taken into account (see ref. 1, pages 219-223). Similarly it is usually found that thermoplastic pipes cannot be treated as thin-walled; then it is necessary to use the methods for thick vessels under pressure (ref. 1, pages 278-280) or hollow cylinders under direct bearing (ref. 1, page 299).

The elastic constants of metals are affected by drawing, rolling, annealing etc.; in the same way, the properties of thermoplastics are affected by the fabrication conditions. Many of these effects are complicated, but the following are well understood in a general way:

1. The amount of crystallinity in the semi-crystalline plastics —polythene, polypropylene, nylon, and p.t.f.e.—is not a



Figs. 3 (a) and (b). Young's modulus over a range of temperatures for various plastics.

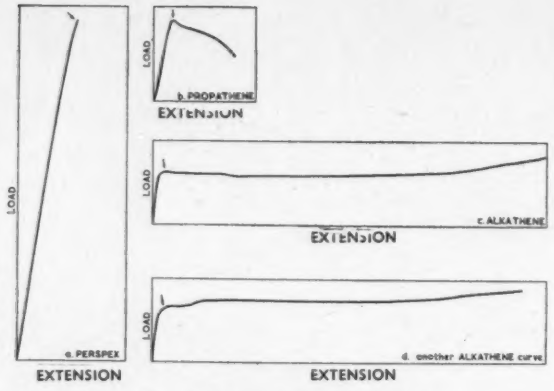


Fig. 4. Some basic types of tensile - load / extension curve.

Fig. 5. The two basic types of curve found in flexural tests.

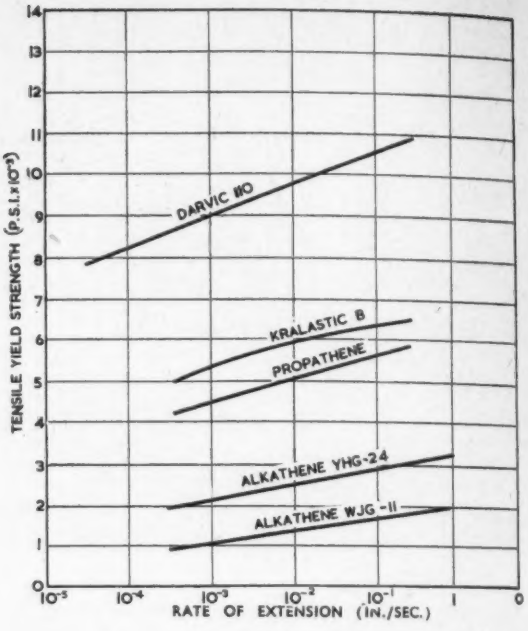


Fig. 6. Effect of rate of extension on tensile yield strength.

constant, but can be changed by altering the rate of cooling from the molten state during fabrication. Thus rapid cooling leads to lower crystallinity and so to a lower modulus. The amount of crystallinity may increase after moulding.

2. During fabrication, the molten material may flow in a particular direction. The molecules become somewhat aligned in this direction and when the material solidifies, this orientation becomes frozen into the article. This anisotropy has the effect that the modulus along the direction of orientation is different from that in other directions. The anisotropy can be reduced by altering moulding conditions.

3. Nylon, when first moulded, is completely dry, but after extraction from the mould, the piece gradually absorbs some water. Consequently, its modulus falls for a period after moulding, but then becomes constant as it reaches equilibrium with the atmospheric humidity.

Tensile Strength

Thermoplastics give several different types of load-extension curve when tested in tension at a constant straining rate. Fig. 4 shows some examples; there are no scales because it is the shape of the curve that matters. The Perspex specimen (4a) broke at about 3½% extension, in a brittle manner. The tensile strength can clearly be determined quite simply from the maximum load. The load on the Propathene specimen (4b) rose to a peak and then fell as the specimen necked. Again, the tensile strength can be determined from the maximum load, but in this case it is referred to as a yield strength, whereas the tensile strength of the Perspex specimen is called a brittle strength. The curve for the first Alkathene specimen (4c) has a peak, but after necking the specimen extended for several hundred per cent and the load rose above the yield strength. It would be wrong to calculate the tensile strength from the load at break because such large extensions could not be tolerated in practice. Consequently, the yield strength is quoted as the tensile strength. The curve for the second Alkathene specimen (4d) shows that it also broke after large extension, but there is no peak at the yield point. The load-extension curve for Fluon may also be of this type. For this class of material the stress at break would again not be a practical quantity to quote; the stress at the bend in the curve is used as the tensile strength. In Fig. 4(a) to (d), an arrow indicates the point in the curve used to calculate the tensile strength.

As is done for Young's modulus, it is necessary to allow for temperature and straining rate when quoting tensile strength. Fig. 6 shows the yield strength of some plastics at 20 deg. C. over a range of rates of extension. Fig. 7 shows some yield strengths determined over the important temperature range at a straining rate of 3% per second. Brittle strengths are not shown in these two Figs. because it is more convenient to determine them accurately in flexural tests.

The yield strength depends, in the same way as Young's modulus, on fabrication conditions and water content.

Flexural Strength

In flexural tests on plastics, there are two basic types of load-deflection curve. Fig. 5 shows examples of the two types, which were obtained in three-point loading bend tests at 20 deg. C. (deflection speed 18 in. per minute). The Perspex curve (5a) rises to a maximum load, and then the specimen breaks in a brittle manner. The flexural strength calculated from the maximum load by the usual formula* is higher than the tensile brittle strength determined under similar conditions. This is usually attributed to the fact that the effective volume under high stress is so much smaller in the flexural test. The Darvic curve (5b) rises to a maximum load but the specimen does not break; instead, it is pulled out of the apparatus. If the flexural strength is calculated from the maximum load by the same formula, the result is higher than the tensile yield strength but for a different reason. In this type of bend test, unless the ratio of span to

*Bending moment ÷ section modulus.

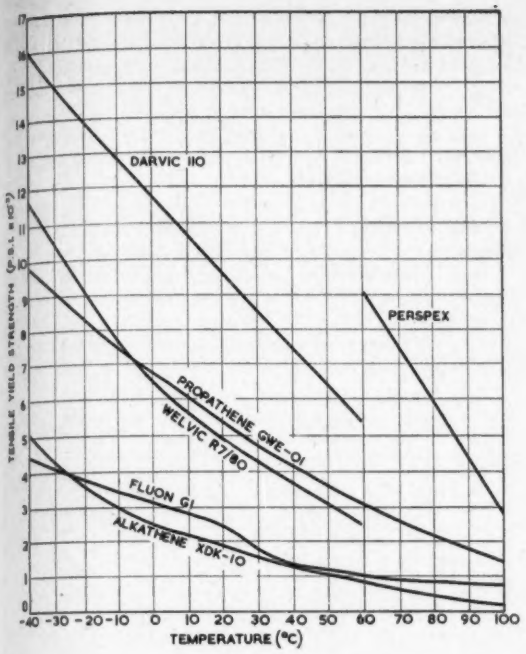


Fig. 7. Effect of temperature on tensile yield strength.

thickness is high, the load does not fall until the regions of tensile and compressive yield meet in the middle of the specimen. Fig. 8 is a photograph of a Darvic specimen in which this can be seen to have occurred.

The flexural strength varies with temperature and testing speed in the same way as does the tensile strength. Figs. 9 (a) and (b) show the flexural strengths of various plastics over a range of temperature.

The flexural yield strength varies with fabrication conditions and water content in the same way as do the tensile yield strength and Young's modulus. The brittle strength is affected by even more variables[3]:

1. If semi-crystalline plastics are cooled slowly from the melt during fabrication, their yield strengths are higher but their brittle strengths lower than if they are rapidly cooled.
2. The brittle strength is reduced by increasing the volume of the test specimen.
3. The brittle strength is reduced by reducing the molecular weight, but this has no direct effect on the yield strength. It should be noted that, apart from molecular weight differences in the starting material, it is possible to lower the molecular weight, and therefore the brittle strength, by degradation during fabrication, aging or irradiation.
4. If a moulded article has some residual strain, as mentioned previously, the brittle strength depends on the direction of test. It will be higher in the flow direction than perpendicular to it. Fig. 10 illustrates this by showing the flexural strength of Diakon tested along and across the direction of flow in an injection-moulded article. It is clear that, in practice, the lower value will be more important.

Owing to effects of this type the brittle strengths are not material constants, and the values given here can be taken only as indications.

Compressive Strength and Shear Strength

Because the various properties of thermoplastics depend so much on temperature, rate, strain, fabrication conditions, etc., it requires a great deal of effort to determine them. It is a great help, therefore, if there are reliable relationships which can be used to reduce the experimental work. This can be done, to some extent, with the compressive and shear strengths.

For metals, there is good experimental evidence that the yield point obeys the criterion associated with Huber, Hencky and von Mises. This gives the following relations[4]:

Compressive strength = tensile yield strength
Shear strength = tensile yield strength $\div \sqrt{3}$

Some unpublished measurements made in the I.C.I. laboratories suggest that it is satisfactory to apply these relations to thermoplastics, but there are three points to be noted:

1. Hollow compression specimens, and solid specimens which are too long and narrow, may buckle at stresses below the yield strength, because of elastic instability. Clearly, such experiments do not give the compressive strength.
2. If the material is brittle in tension, the relationship cannot be used, because the tensile yield strength cannot be measured. It is then necessary to measure either the compressive strength or the shear strength—the other may then be calculated from the relation:

Shear strength = compressive yield strength $\div \sqrt{3}$

3. Strengths are usually quoted as conventional stresses which are calculated by dividing the load by the original cross-sectional area. On the other hand the yield criterion applies to true stresses, which are calculated by dividing the load by the actual cross-sectional area under load. Consequently, although the true compressive strength is equal to the true tensile yield strength, the conventional compressive strength will be 10 to 20% higher than the conventional tensile yield strength. This is another consequence of the fact that the yield strain is much higher for plastics than for metals. For example, experiments on Darvic specimens, at 20 deg. C. and a fairly low rate of strain, gave the following results:

Conventional compressive strength	10.3×10^3lb./in.^{2}
Yield strain in compression	5%
therefore, true compressive strength	9.8×10^3lb./in.^{2}
Estimated conventional tensile yield strength	9.3×10^3lb./in.^{2}
Estimated shear strength	5.7×10^3lb./in.^{2}
Measured tensile yield strength	8.3×10^3lb./in.^{2}
Measured shear strength	6.0×10^3lb./in.^{2}

Impact Strength

The impact strength is usually taken to mean the energy needed to break a specimen under standardised conditions of test. These conditions may be, for example, those of the Izod impact test, either American[5] or British[6], and the result of this test is often quoted as "the impact strength" of a material. A single figure such as this is useless for engineering design; it is necessary to go into more detail, and consider the conditions of the intended application.

Some useful preliminary information may be obtained by measuring the energy to break in a flexural test over a range of temperatures. Fig. 11 shows some results for three plastics, obtained in a three-point loading test at 18 in. per minute. It is particularly true of the energy to break that results are dependent on test and fabrication conditions, so these graphs can only be taken as rough indications of material behaviour. However, it can be seen that there is a transition region, similar to that found for metals, in which the energy to break changes from a low value, corresponding to brittle fracture, to such a high value that the specimen does not break in the test. The most important single fact to be considered about impact behaviour is the position of the conditions in service relative to the conditions at the tough-brittle transition region.

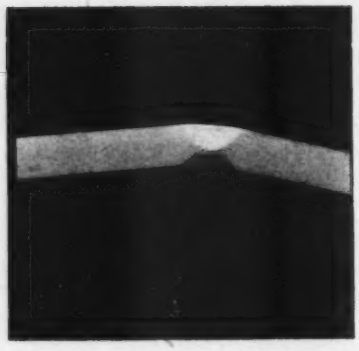


Fig. 8. This Darvic beam was tested in three-point loading. The light region indicates yielding in tension, and the dark region indicates yielding in compression. Note that they have met in the centre of the beam.

When the transition temperature is so high that the material is brittle in this flexural test, the test is particularly useful for comparing materials, and for providing data for engineering design. The flexural strength and energy to break can both be determined from the recorded load-deflection curve; Table 2 gives some illustrative figures.

For materials which are tough in this test at room temperature, the energy is not a suitable criterion, because tough fracture is very rare in service. In fact, no single test result, or even a single graph, is sufficient for a proper understanding of the impact behaviour of tough plastics. So many factors affect test results and resistance to shocks in service that it is not possible to rate materials in order of toughness; the order will be different under different conditions. Rational engineering design can only come from an understanding of the principles involved. The situation is somewhat similar to the problem of brittle fracture in mild steel; this has been thoroughly studied, and many different factors affecting the chance of brittle fracture have been discovered and described[7]. Some of the same factors affect the chance of brittle fracture in plastics.

Temperature: As the temperature is reduced the yield strength of plastics or steel increases, and there is more chance of brittle fracture (see Figs. 7 and 11).

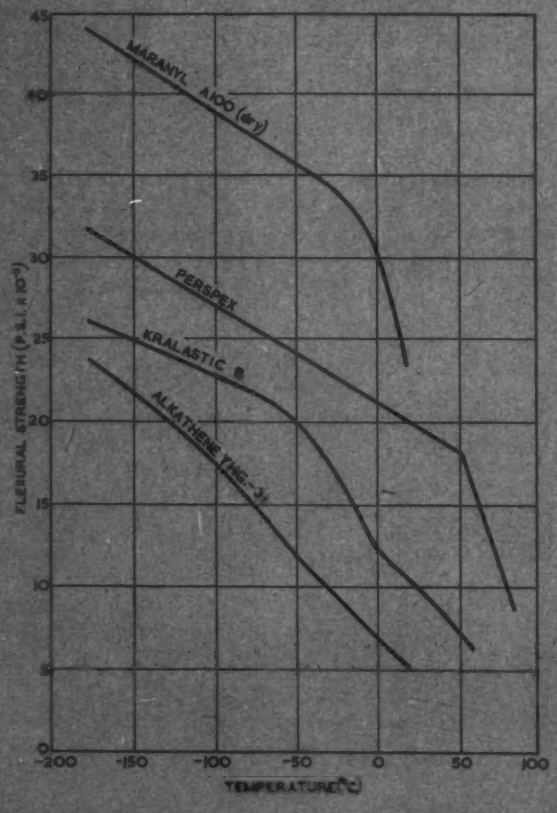
Speed: The effect of increasing the rate of test, or the speed of a blow in service, is similar to the effect of reducing the temperature.

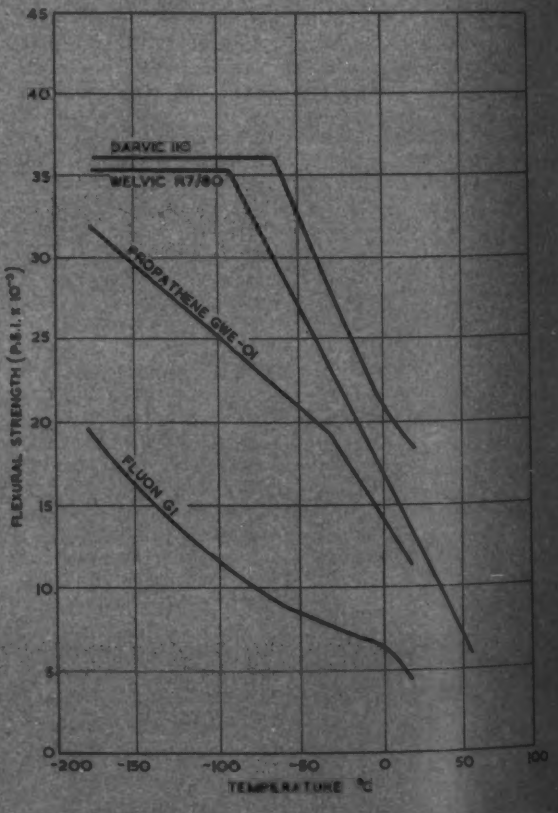
Type of Stress: The chance of brittle fracture is very dependent on the type of stress applied. It is very unlikely

Table 2. Typical values for flexural strength and energy to break (at 20° C. and 18 in./min.).

Material	Direction of test	Flexural Strength ($lb./in.^2 \times 10^{-3}$)	Energy to Break ($ft.\,lb./in.^2$)
Maranyl A 130/E	Along flow direction	42·0	62
Perspex	—	19·8	40
Diakon MG	Across flow direction	16·5	25
Mouldrite	—	15·2	10
Toughened glass	—	34·8	9
Polystyrene	Across flow direction	8·2	6
Pine wood	Across grain	1·0	3·2
Ordinary glass	—	18·4	1·4

Figs. 9 (a) and (b). Flexural strengths of various plastics over a temperature range.





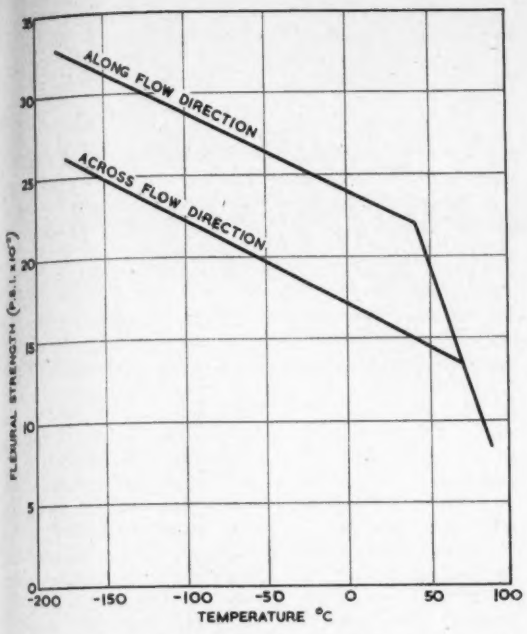


Fig. 10. Flexural strength of Diakon tested along and across the direction of flow.

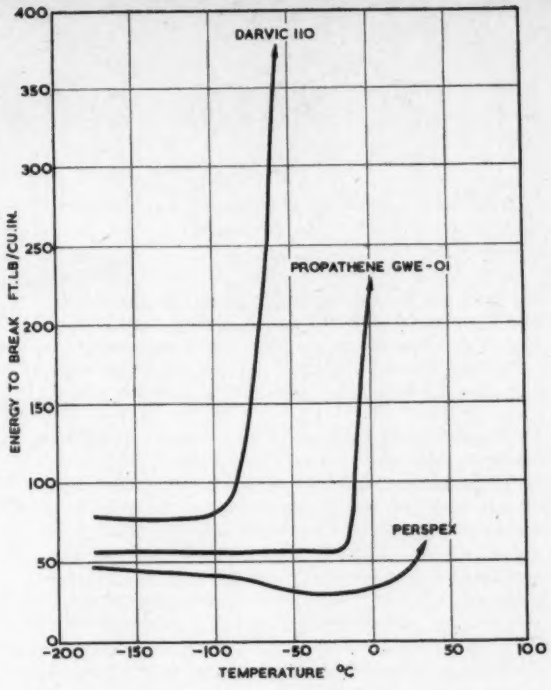


Fig. 11. Energy to break of various plastics over a range of temperatures.

in compression or shear, more likely in tension, and still more likely in bi-axial tension, as in the bending of flat plates. Notches, sharp corners and other regions where shear deformation is hindered are very powerful promoters of brittle fracture, and should always be avoided if at all possible. The effect of notches can be illustrated by means of a polycarbonate sheet tested in the I.C.I. laboratories. In a normal bend test the material was not brittle at –180 deg. C., but with a sharp notch it broke in a brittle manner at +20 deg. C.; the notch increased the transition temperature by over 200 deg. C. It is clear that every effort should be made with plastics, as with all solids, to avoid notches and sharp corners and to permit shear deformations.

Orientation: Fig. 10 has already shown the effect on the flexural brittle strength of Diakon of testing along and across the direction of flow in an injection moulding. The chance of brittle failure depends on the lower strength, and this is reduced by increasing the residual strain. In other words, highly strained articles will tend to be brittle. This is always true for thermoplastic mouldings, and it suggests that fabrication conditions should be chosen to reduce residual strain. For example, the strain is reduced by increasing the temperature of the molten plastics during injection moulding. This increase of temperature may cause other difficulties, and a compromise is needed.

Molecular Weight: Low molecular weight, whether basic or caused by degradation, reduces the brittle strength and so tends to promote brittle failure.

Crystallinity: Increasing crystallinity increases the yield strength, and therefore increases the chance of brittle fracture.

Slow Cooling: Apart from any increase of crystallinity, slow-cooling of crystalline plastics reduces the brittle strength and so tends to promote brittle fracture. This suggests that it is advantageous to cool the mould as much as possible, when injection moulding. This, again, may cause other difficulties, and a compromise is needed.

It is clear from this summary of the factors affecting brittle fracture that designing for toughness is not a matter of using a single arbitrary figure, nor of detailed calculation, but of understanding and applying certain general principles. Because the problem is so complicated it is often worth testing samples of the final moulded article.

Appendix

The following materials have been mentioned:

Perspex	Polymethyl methacrylate of high molecular weight in the form of bulk cast sheet.
Diakon	Polymethyl methacrylate of lower molecular weight in the form of injection mouldings.
Welvic R7/80	Polyvinyl chloride with a synthetic rubber additive to give improved impact strength. Compression-moulded sheet was used.
Darvic	Polyvinyl chloride in the form of calendered sheet.
Propathene	Polypropylene. Extruded sheet was used.
Alkathene	Polythene. Compression and injection mouldings were used.
Fluon	Polytetrafluoroethylene. Compression-moulded sheet was used.
Maranyl A/100	66 nylon. Injection mouldings were used. Maranyl A/130 has glass fibre added.
Kralastic	A co-polymer blend of acrylonitrile, butadiene and styrene. Compression and injection mouldings were used.
Mouldrite	Urea-formaldehyde resin. Compression moulded.

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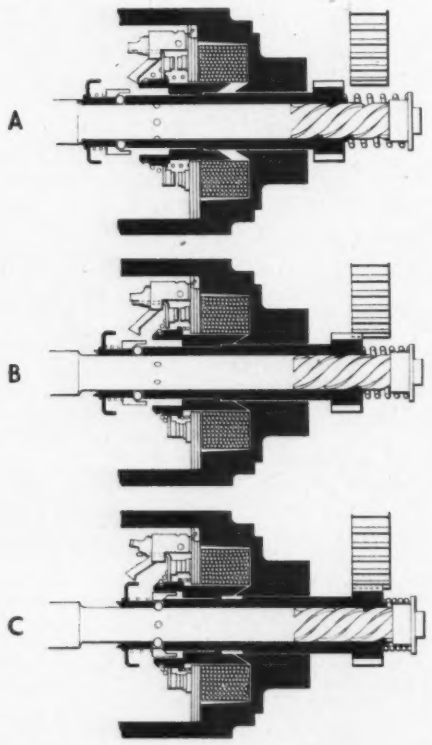
AT THE MOTOR SHOW

THE trend at this year's Motor Show appeared to be towards increasing the comfort of the driver, thereby helping to reduce driving fatigue.

With higher cruising speeds, the new motor-ways and the variation in road surfaces, the means for selecting the best type of ride is important. A new electrically-controlled adjustable suspension system has been introduced by Armstrong Patents Co. Ltd. which enables four degrees of suspension to be obtained—soft, firm, and two intermediate positions.

A recent development in braking systems has been the use of vacuum power obtained from the induction system to reduce the foot pressure needed on the brake pedal. The Girling system involves either a unit which can be added to the linkage of mechanically-operated brakes, or one which carries tandem master cylinders for hydraulically-operated brakes. In both cases the vacuum cylinder is so arranged that full manual effort can be applied in the event of loss of vacuum when the engine has stopped. Lockheeds have also developed a similar device for hydraulically-operated brakes using a rolling-diaphragm type of sealed vacuum piston.

The C.A.V. co-axial starter has been designed to enable the starter pinion to engage with the starter ring on the engine flywheel while under reduced power, thus avoiding heavy engagement shock and excessive wear of the gear teeth. When the starter switch is operated, a solenoid (mounted co-axially with the armature) is energised, causing a hollow plunger to push the pinion towards the starter ring. At the same time the movement of the plunger closes a pair of contacts connecting the field winding through a resistance to the battery, thus causing the armature to slowly revolve. This combination of forward and rotary movement partially engages the pinion with the engine flywheel teeth. The pinion is then prevented from rotating by the stationary flywheel, and is drawn fully into mesh by the helix on the slowly rotating armature shaft. Just before the fully engaged position is reached a collar on the end of the pinion trips a second pair of contacts, which shorts out the resistance and allows full current to flow to the motor. The pinion is held in positive mesh by a locking device which consists of four steel balls located in the pinion sleeve. When the pinion is in the fully forward position, the balls drop into recesses in the armature shaft, and are held in that position by a spring-loaded collar which slides over them. When the starter button is released and the solenoid de-energised, the plunger returns to its normal position, and in so doing pushes back the collar and releases the balls. To ensure that the pinion does not jam if it and the flywheel ring become worn and meet tooth to tooth, a recoil mechanism is fitted by means of which the armature is permitted to float axially—this allows the pinion to free itself from any burrs and return to its normal position.



The C.A.V. co-axial starter (type CA45c), showing three stages of engagement and locking of the pinion in mesh with flywheel gear ring.

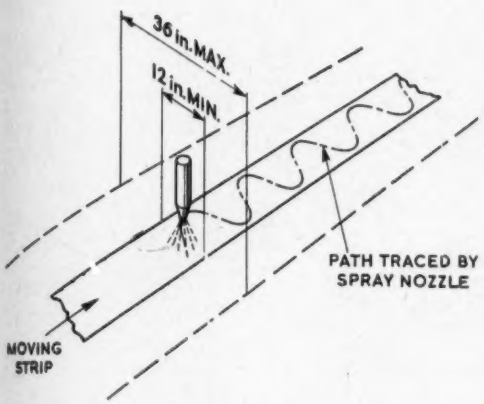
The new electric impulse tachometer shown by Smiths Motor Accessory Division utilises the frequency of the make-and-break of the distributor contact breaker. The current pick-up from the low-voltage side of the ignition circuit ensures instrument accuracy by employing as a triggering pulse the actual current required by the ignition coil to produce each spark.

Since the preliminary winding of the triggering or current transformer is in series with the primary of the ignition coil, when the contact breaker closes, the current flowing to feed the ignition coil passes through the primary of this transformer, thereby energising its core. When the contact breaker opens to provide a spark to the engine, the flux in the transformer core collapses and the core energy appears as a short-duration voltage pulse across the secondary winding of the transformer. This triggers one of the transisters in the circuit, allowing a second transistor to be switched on for a fixed time period, and thereby permitting current to flow from the battery to the indicator. The instrument cannot be affected by eddy currents in the high-tension side of the ignition circuit, by the distributor contact breaker setting, or by erosion of the sparking plug points or excessive difference in gap settings.

Another aid to comfortable motoring is the re-introduction of a reserve fuel valve. This new valve by Smiths is electrically operated from the dashboard, and enables a reserve supply from the bottom of the tank to be brought into use. At the same time a warning light glows on the instrument panel, and remains alight until the valve is switched back to its normal position for main fuel supply.

The new Bristol 407, with a 5-litre V-8 Chrysler engine, incorporates pushbutton automatic transmission. From the illuminated pushbuttons a choice of low, intermediate, high, reverse and gear hold can be made, the latter permitting engine braking. Part of the side valance between the front door and front wheel is hinged upwards on this car, thus introducing a new approach to the problem of spare wheel and battery storage, and allowing easy access to these components.

PROBLEMS IN DESIGN



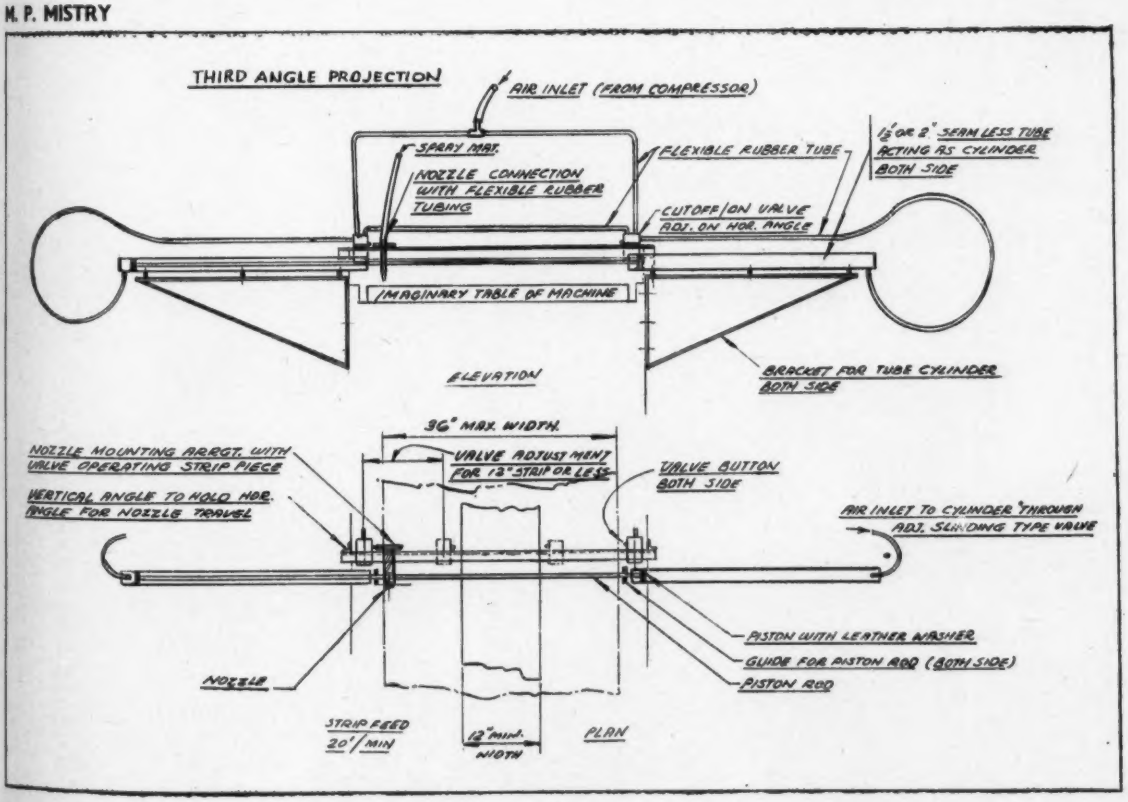
Problem No. 22 (August):

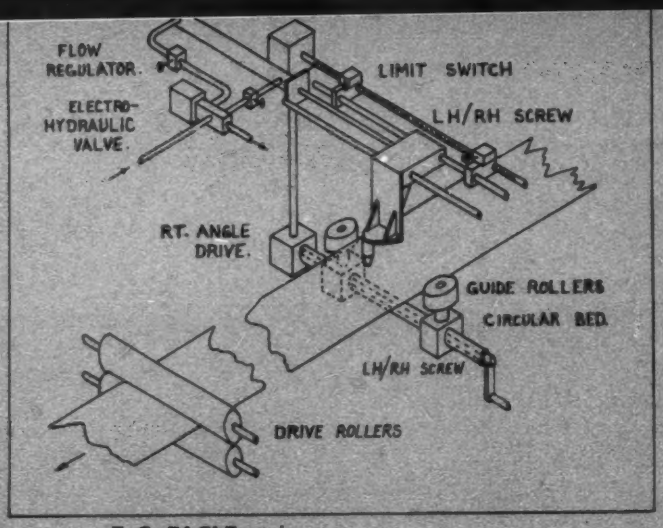
In a special-purpose machine for the continuous production of strip material, it is necessary to provide a means whereby a spray nozzle can be slowly reciprocated across the travelling strip material to provide a coating of reasonably even thickness. The material, however, varies in width from 12 in. minimum to 36 in. maximum.

Devise a simple mechanism which will enable the amplitude of lateral reciprocation of the spray nozzle to be varied while running, within the above limits. The speed of the nozzle is to be constant at approximately 20 ft./min. (The mechanism for varying the speed of the strip need not be shown.)

Although the above problem involves alteration to the amplitude of movement of a reciprocating element, this requirement differs from other problems of a similar character which have appeared in previous issues. For the speed of the spray nozzle to be constant, it is essential that reversal take place almost instantaneously in order that the

M. P. MISTRY


THIRD ANGLE PROJECTION
AIR INLET (FROM COMPRESSOR)
SPRAY MAT.
NOZZLE CONNECTION WITH FLEXIBLE RUBBER TUBING
FLEXIBLE RUBBER TUBE
1½ OR 2" SEAM LESS TUBE ACTING AS CYLINDER BOTH SIDE
CUTOFF/ON VALVE ADJ. ON HOR. ANGLE
IMAGINARY TABLE OF MACHINE
ELEVATION
BRACKET FOR TUBE CYLINDER BOTH SIDE
36" MAX. WIDTH
NOZZLE MOUNTING ARRGT. WITH VALVE OPERATING STRIP PIECE
VALVE ADJUSTMENT FOR 12" STRIP OR LESS
VALVE BUTTON BOTH SIDE
VERTICAL ANGLE TO HOLD HOR. ANGLE FOR NOZZLE TRAVEL
AIR INLET TO CYLINDER THROUGH ADJ. SLIDING TYPE VALVE
PISTON WITH LEATHER WASHER
GUIDE FOR PISTON ROD (BOTH SIDE)
PISTON ROD
NOZZLE
STRIP FEED 20'/MIN
12" MIN. WIDTH
PLAN



F. S. EAGLE △

strip be coated with a uniform thickness of sprayed material. For this reason a mechanism having a sinusoidal velocity diagram would not be suitable. Most of the readers who submitted entries had grasped this fact and employed either hydraulic or pneumatic cylinders, or alternatively leadscrews or chain drives, to move the nozzle carriage.

M. P. Mistry, of Bombay, India, chose two compressed cylinders to actuate the spray nozzle, which is fixed to the common piston rod. The nozzle carriage actuates each two-way valve in turn, the valves being clamped, at the appropriate width apart, to a piece of angle. This solution is straightforward and simple, and could be easily made. The addition of a pressure controller would ensure that fluctuations in the air pressure did not affect the speed of reciprocation of the nozzle. The mechanism would, however, be rather wide—more than 9 ft.

▽ **H. R. HORTON**

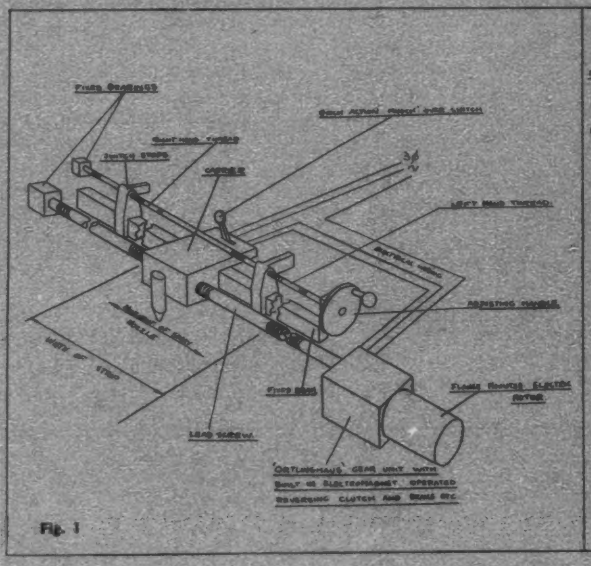


Fig. 1

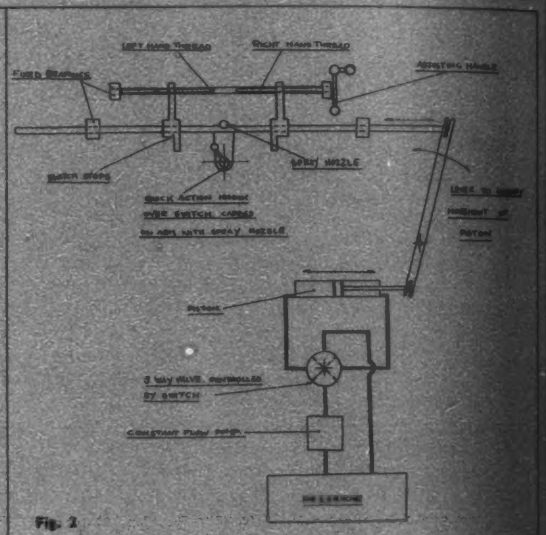
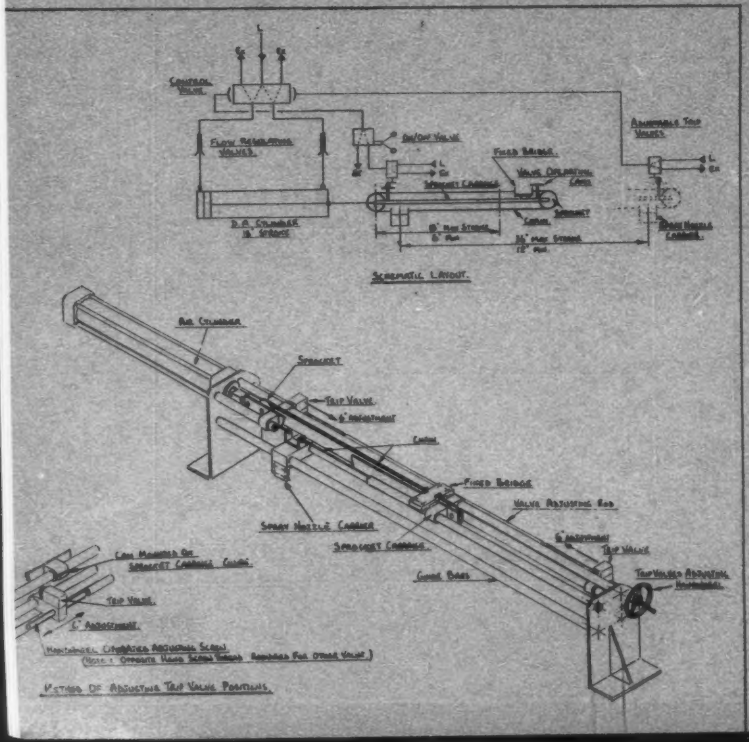
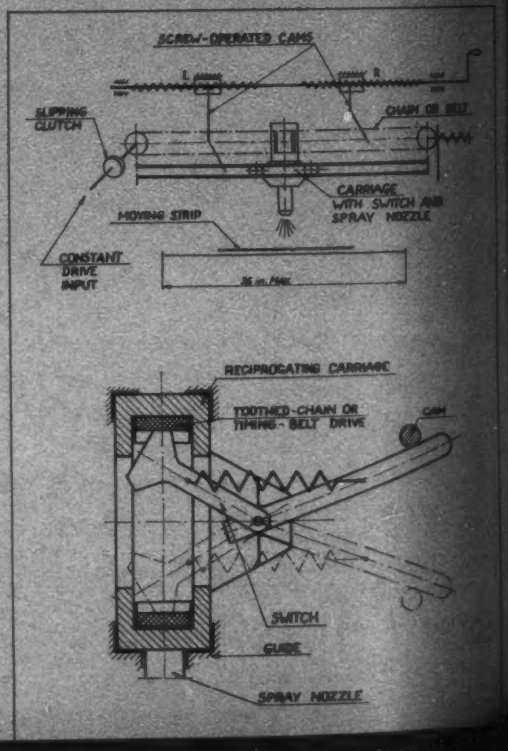


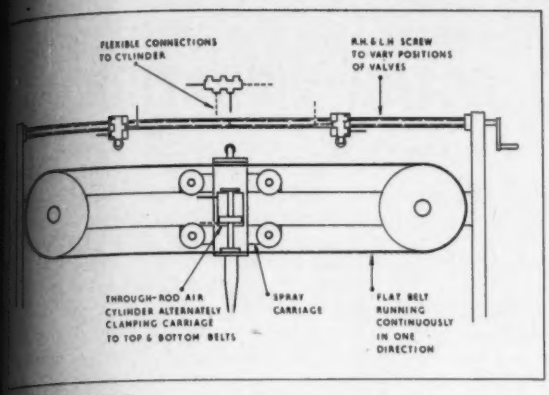
Fig. 2

D. LIGHTFOOT ▽

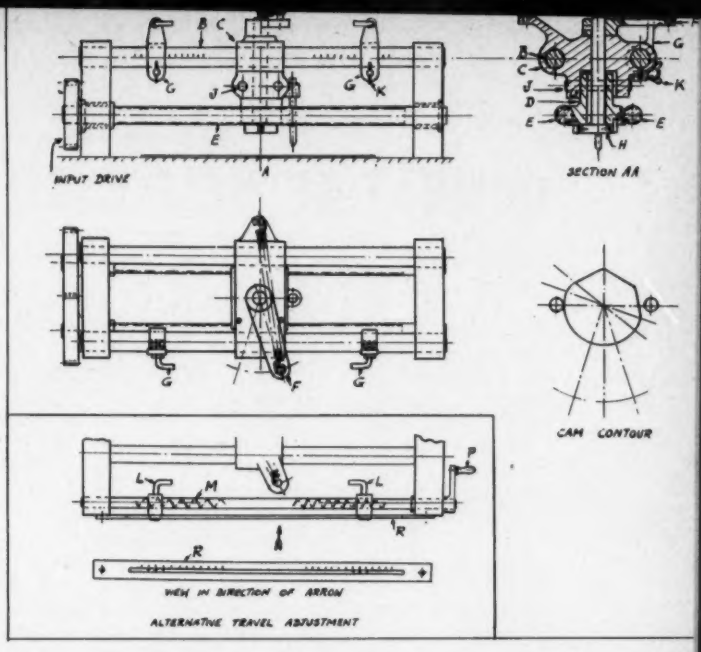


▽ **B. MAJOROS**




FLEXIBLE CONNECTIONS TO CYLINDER
R.H. & L.H. SCREW TO VARY POSITIONS OF VALVES
THROUGH-ROD AIR CYLINDER ALTERNATELY CLAMPING CARRIAGE TO TOP & BOTTOM BELTS
SPRAY CARRIAGE
FLAT BELT RUNNING CONTINUOUSLY IN ONE DIRECTION

O. W. BEWS



E. CLAYTON

A more elaborate entry from **D. Lightfoot** also employs air, but an attempt has been made to reduce the overall width of the mechanism. A single air cylinder of 18 in. stroke is used. The piston rod actuates a chain drive assembly which is caused to reciprocate along guide bars. The 18-in. stroke length is doubled, for the movement of the nozzle, by anchoring the upper ends of the chain to a fixed bridge on the carriage slide bars, the spray nozzle carrier sliding on another guide bar slightly below those carrying the chain drive. The valves are mechanically operated by cams fitted to the sprocket carriage. The valves are adjusted, for distance apart, by a left- and right-hand screw operated by a handwheel.

A simple scheme (see Fig. 1) from **H. R. Horton** employs a lever to magnify the movement of an hydraulic actuator. A three-way electrically-operated valve is actuated by a knock-over switch carried on the spray nozzle arm. The switch stops are brought together or drawn apart much as in Mr. Lightfoot's entry. Mr. Horton's second entry (Fig. 2) is on mechanical lines, and uses an Ortlinghaus gear unit with built-in electromagnet-operated reversing clutch and brake, the spray nozzle being fixed to a carriage which is reciprocated by a leadscrew. A knock-over switch is operated as in the previous entry. Although both schemes are thoroughly practical, they would entail more expense than an air-operated mechanism. Compressed air, however, is not always available.

F. S. Eagle's entry, using a single hydraulic cylinder with a two-position electrically-operated valve, incorporates an additional refinement. Control of the amount of nozzle reciprocation is by means of a handwheel which, via two right-angle drives, simultaneously controls both the distance apart of the limit switches and also the space between two guide rollers for the strip material. This ensures that the strip is always correctly positioned in relation to the nozzle. This feature could be made fully automatic by the addition of a strip-width sensing device and a gear drive to the guide rollers.

R. C. F. Skelton employed a reversing chain drive to one side of which the nozzle carriage was attached, reversal being brought about by adjustable limit switches and a reversing relay. Drive was from a reversing motor. This, we felt, was an effective but costly solution.

E. Clayton avoids electrical limit switches, the whole carriage mechanism being mechanically operated. Two leadscrews, geared together, are driven at the required speed by an electric motor. The nozzle carriage is caused to reverse by the alternate engagement of a double half nut *D*, first with one lead screw, then with the other. This, reversal is brought about by a cam *H* and actuated by a toggle lever *F* as it strikes first one and then the other of the adjustable stops *L*.

B. Majoros, of Budapest, Hungary, illustrates another wholly mechanical solution. A chain, or belt, running the full width of the machine, is gripped by a toggle clamp first on its upper side, then on the lower. The toggle clamp forms a part of the nozzle carriage. Adjustable cam pieces actuate the toggle lever. **O. W. Bews** also used a belt and clamping device, but operated the latter by an air cylinder on the carriage.

Other possible solutions, having electrical and mechanically-operated clutch systems, were received from **M. M. Glide** and **D. T. Elliot,** the first employing a reversing leadscrew, and the second a reversing chain drive.

PROBLEM IN DESIGN No. 26
Here is this month's problem

In a fully-automatic domestic appliance, a solenoid-operated valve for the admission of hot or cold water is required. The water pressure can vary between 5 and 120 p.s.i., but the force required to operate the valve is limited by the solenoid which exerts 6 oz. only. The inlet and outlet branches of the valve are $\frac{1}{2}$ in. dia.

Suggest, by means of a sectional drawing, the kind of valve that would meet these conditions. It should be remembered that the domestic appliance is for competitive economic production in quantity.

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12×12 in., please!) to the Editor, "Problems in Design No. 26 (December)". Closing date January 20.

COMBATING SELF-EXCITED ROTOR VIBRATION

The present-day tendency to increase the operational range of turbo-machinery above the first critical speed of the rotor has necessitated the solution of several difficult problems, one of which is the danger of self-excited rotor vibrations.

by ALEŠ TONDL*

SELF-EXCITED vibration, often called "oil whip", is initiated by the instability of vibrations caused by rotor unbalance, and can appear only at speeds higher than the first critical speed of the rotor. Its occurrence, unlike that of the critical speed, is not limited to a narrow speed interval, but in the majority of cases appears within a wide range of speeds of which the lower limit equals roughly twice the rotor critical speed. This is dangerous because their amplitude is almost always large.

The phenomenon of self-excited vibrations has been studied by both theoretical analysis and experimental methods. The effects of various factors, such as viscosity of the lubricating oil, specific load, etc., have also been studied. and methods sought by which self-excited vibrations may be suppressed. Various designs of bearing which would have higher resistance to the generation of these vibrations than ordinary cylindrical bearings have also been studied.

It was found that in this respect better characteristics are obtained with elliptical bearings (see Fig. 1), and particularly with special bearings, such as fixed-pad bearings (see Fig. 2), multi-lobe bearings (see Fig. 3), and a version of the Michell tilting-pad bearing (see Fig. 4). The manufacture of these bearings is, however, much more exacting than that of the plain cylindrical type. This fact led the author to design a bearing which is far more easily manufactured, but which performs the same function as the types mentioned above.

During rotation the pressure in the lubricating oil film causes elastic deformation of the elements, and consequently the formation of the necessary wedge gaps. Fig. 5 shows a schematic representation of the element deformation and the pressure distribution in the bearing oil film. The pressure distribution is plotted so as to include the sub-pressure regions; i.e. it is assumed that they are not cancelled by the pressure of the incoming oil. The bearing is shown in a section through the radial cut of the shell. Originally these bearings were only designed for the sense of rotation shown in Fig. 5, namely in the direction against the free ends of the flexible elements. Tests carried out with the shaft rotating in the opposite direction have however produced interesting results, with very favourable features as regards bearing resistance to self-excited vibrations.

The intensity of the self-excited vibration is measured chiefly by its amplitude. In the majority of cases these amplitudes were much smaller in the flexible-element bearings than in the elliptical and particularly in the cylindrical bearings. Another criterion for the intensity of the self-excited vibration is the velocity of its initiation and the character of the transition. In cylindrical bearings the self-excited vibration appeared suddenly, and its amplitude grew rapidly according to an exponential law.

The three-element bearings (see Fig. 6) were superior to the four-element design (see Fig. 4) in their resistance to the initiation of self-excited vibration. All designs and arrangements had one characteristic in common, namely that the limit of the initiation of self-excited vibration depended to a considerable degree upon the temperature of the lubricating oil—particularly so in the case of three-element bearings.

The limit speed associated with the initiation of self-excited vibration was much higher with the journal rotating in the opposite direction than with rotation against the free ends of the flexible elements. In one instance no self-excited vibration was initiated at any temperature of the lubricating oil. In the majority of tests the vibration amplitude was low, and the transition at the initiation smooth.

Evaluation of Load-carrying Capacity

The evaluation of the load-carrying capacity of the bearing was based on the measured trajectories of the journal

*Czechoslovak National Research Institute of Heat Engineering.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

motion at various speeds, and at various journal loads.

For rotation in the direction against the free ends of the flexible elements, the load-carrying capacity of the flexible-element bearings was the same as that of cylindrical and elliptical bearings. For rotation in the opposite direction it was lower, particularly in the case of higher specific loads, greater element flexibility and lower rotor speeds.

With low specific loads and higher speeds there was no observable difference between the two directions of the journal rotation, as far as the ratio a of the eccentricity e of the trajectory centre to the radius of the bearing clearance δ ($a=e\div\delta$) was concerned.

Thus when designing a bearing, one should consider not only its resistance to self-excited vibration but also the required load-carrying capacity and the type of duty for which it is intended, such as occasional operation at low speeds, e.g. when turning the turbine rotor prior to the start of the machine.

Results of Measurements on a Combined Flexible-element Bearing

Good load-carrying capacity associated with the journal rotating against the free ends of the flexible elements, and high resistance to the initiation of self-excited vibration characteristic for the opposite direction of rotation, suggested the utilisation at least to some extent of the advantages of both arrangements, and the combination of the flexible elements so that some of them on deformation increase the load-carrying wedge of the lubricating oil while others reduce it.

The bearing shown schematically in Fig. 7 is an example of the three-element type, with only one element in the upper shell oriented with its free end in the direction against the journal rotation. The lower shell carries two elements, the left-hand one oriented the same way as that in the upper shell, and the right-hand one the opposite way. Fig. 8 is a schematic drawing of the bearing in operation when the elements are deformed, with the assumed distribution of pressure on the journal periphery plotted in the drawing.

Self-excited vibration was only observed within a definite speed range, i.e. there existed both upper and lower limits of its occurrence. Its intensity was relatively low, so that the rotor was easily run through its range to speeds where self-excited vibration could not be initiated even by tapping the rotor.

From the results discussed above it follows that flexible-element bearings possess high resistance to the initiation of self-excited vibration of the rotor. It is possible to combine the flexible elements so that both high resistance to the initiation of self-excited vibration, and very good load carrying capacity, are obtained. Yet bearings of this design are no more exacting in manufacture than cylindrical or elliptical bearings. Thus flexible-element bearings can replace present designs which, although highly resistant to the initiation of self-excited vibration, are more complex and demanding from the manufacturer's point of view.

Loose-bush Bearings

Further studies were carried out using flexible and cylindrical bushes loosely fitted into a housing. In this type of bearing the working bushing is inserted with a clearance into the fixed bearing shell. In the clearance between the loose bushing and the shell a pressure oil cushion damps the motion of the bushing. At each displacement of the bushing, oil is pressed from one side to the other as in a dash-pot. Additionally, each displacement from the equilibrium position induces a restoring force which returns the bushing into its initial position.

When this bearing was designed, the loosened bushing placed into a cushion of pressure oil was expected to provide two advantages over a similar fixed bushing: increased damping and hence higher resistance to the initiation of self-excited vibrations; and better cooling of the working bushing with flowing oil. Tests have shown that both expectations are fulfilled.

The bearings to be tested were made with two different types of working bushing. In the first case the bushing was cylindrical with three longitudinal cut-outs to facilitate the ingress of lubricating oil; in the second case it contained three equal flexible elements arranged symmetrically and produced by radial and axial cut-outs, as previously described.

The working bushing was loosely fitted into the fixed shell with no protection against possible rotation. A capacitive pickup especially designed was placed in the body of the bearing pedestal to indicate if there was any rotation of the bushing.

Rotation of the loose bushing was sometimes experienced in the bearing with smaller clearances ($2\delta=0{\cdot}20$ mm, $2\delta_0=0{\cdot}20$ mm).* In such cases the limit of the initiation of self-excited vibrations was considerably increased.

Bearings with a Cylindrical Loose Bushing

Tests were conducted with two pairs of bearings; the first pair had the clearances $2\delta=0{\cdot}20$ mm. and $2\delta_0=0{\cdot}20$ mm., the second pair had $2\delta=0{\cdot}30$ mm. and $2\delta_0=0{\cdot}35$ mm. The specific load was 1·65 kg./sq. cm. in all cases.

The limit for the initiation of self-excited vibrations was slightly higher than with fixed cylindrical bushings as long as the rotor shaft was aligned with the driving motor shaft; the results were similar for both directions of rotation. A substantial increase in the limit ratio q_s† (in some cases up to double its value) could be obtained by misaligning the shafts. No difference was found to exist between the limits for self-excited initiation and the limits for initiation due to an external impulse such as tapping.

In the bearing with larger clearances ($2\delta=0{\cdot}30$ mm., $2\delta_0=0{\cdot}35$ mm.) there also existed an upper limit to the initiation

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* 2δ=*diametrical clearance of the journal in the loose bushing;* $2\delta_0$=*diametrical clearance of bushing in the shell.*

† $q_s=n_s/n_0$, *where* n_s=*rotor speed at which self-excited vibrations are initiated, and* n_0=*critical speed of rotor.*

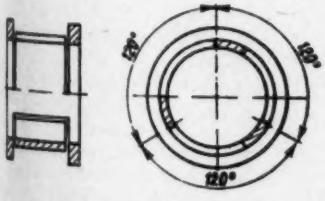

Fig. 6

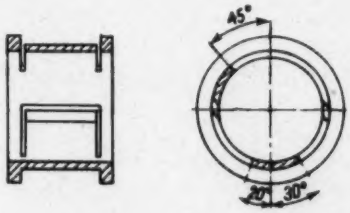

Fig. 7

Fig. 8

of self-excited vibrations beyond which only minor disturbances were observed.

Bearings with a Flexible-element Loose Bushing

When the cylindrical loose bushing was replaced by a flexible-element one, the resistance of the bearing against the initiation of self-excited vibrations was substantially increased. With the journal rotating in the direction towards the free ends of the flexible elements no self-excited vibrations occurred, nor could they be induced by tapping the rotor. Only in certain cases were insignificant disturbances observed, chiefly in the vertical component of the journal motion.

For the opposite direction of rotation (from the free to the fixed ends of the flexible elements) self-excited vibrations did not occur if both clearances (δ and δ_o) were sufficiently large. In bearings with smaller clearances (notably small δ) self-excited vibrations did occur, but the limit of their initiation was high and their intensity low. In all cases the limit was highly dependent on the temperature of the lubricating oil.

As to the load-carrying capacity of the bearing: for rotation in the direction towards the free ends of the flexible elements, the load-carrying capacity of flexible element bearings was considerably reduced at higher loads. With a loose bushing, however, the load-carrying capacity of the flexible-element bearings was good for both directions of rotation. For rotation in the direction from the fixed towards the free ends of the flexible elements; on the contrary, with a smaller internal clearance, the load-carrying capacity was even higher. A comparison of these results with those for a similar bearing with a fixed bushing shows a significant improvement due to the loose bushing.

On the average, the outlet oil temperatures were lower in the loose-bushing bearings than in bearings with a fixed bushing. After disassembly the bearings showed no signs of wear. In some tests the bushing surface was marked with indelible pencil; after operation these marks were neither washed off nor less legible than before.

In practical operation, particularly if the flexible elements are arranged symmetrically, the loose bushings should be locked to prevent rotation.

Conclusion

Of all the types of bearing tested by the author, those with a flexible-element loose bushing possessed the highest resistance to the initiation of self-excited vibrations while maintaining good load-carrying capacity for both directions of rotation.

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Abridged version of an article published in the *SNTL Technical Digest* (Prague), February 1960 and January 1961.

TIMBER ENGINEERING

MOST building owners regard timber as a low-grade material; engineers are frightened by the variability of timber and their ignorance of it. Architects, if they want a "wood" effect, often find it cheaper to clad steel or concrete. Each is shy of the large-scale structural use of timber. The reasons for this prejudice are worth analysing, and the results of such an analysis were set out in a paper presented by Mr. R. J. M. Sutherland at the recent International Conference on Timber Engineering, organised by Timber Development Association Ltd.

Timber was at one time the most important structural material of all; however, lack of research and therefore reliable strength data, and an underlying feeling that no two pieces of timber would react under loading in the same manner, have contributed to the virtual ousting in the U.K. at least, of timber by steel and concrete.

Although research in the U.K. is comparatively static, the great timber reserves of the Continent and Scandinavia have spurred development in those countries. Papers presented at the Timber Conference by French and Norwegian authors defined methods of calculating stresses in glued, bolted and nailed joints. Formulae have been deduced, but further work is required to establish comprehensive data for all the commonly-used timbers.

Particular attention has been paid to the technique of nail gluing, in an effort to reduce the requirement for large expensive clamping fixtures. Providing that a moisture content of approximately 20% is not exceeded, that surfaces are clean and free from cupping or twisting prior to gluing, that nails are properly driven, and that the whole process is carried out by skilled men under controlled conditions, complete reliance may be placed in the joint. It is necessary, beforehand, however, to conduct a suitable series of strength tests on representative materials and joints.

A different aspect of timber utilisation was featured at the recent meeting of the British Association for the Advancement of Science, where a paper entitled "Engineering with Preserved Timber" was presented.

The development of timber engineering has led to the designer and constructer seeking specific recommendations covering combinations of timber, preservatives and glues. There is, however, a vast number of possible combinations yet to be tested.

There are two distinct problems, the first being the preservative treatment of glued timber, and the second the gluing of preservative treated wood. Normally the selection of a correct glue would be based on the service conditions of the finished glued structure, for example a casein glue type to BS 1444 Type A would normally be selected for indoor use, and a urea resin to BS 1204 type MR/GF for conditions of semi-exposure, whereas a resorcinol resin glue to BS 1204 type WBP/GF would be used for full exposure including exposure to chemically polluted air.

Although wood cannot be rendered incombustible by any technique at present in use, steps can be taken to increase its resistance to ignition, and to delay or even prevent its active participation in a fire. Timber which is given the correct and efficient treatment will prove a reliable material able to give a long and lasting life with a minimum expenditure on repairs and replacements.

DESIGN FOR COLD FORMING – A PRACTICAL REALITY

Although a number of papers have been written on cold forming, most of these have come from research organisations. In this article the author outlines the experience gained at Raleigh Industries Ltd., where the process is now a manufacturing reality

by J. F. HARRIMAN*

As early as 1942, cold forming of slugs by a backward extrusion operation was carried out at Raleigh Industries to form the base of a 20-mm. cannon shell. It was not until 1956, however, that the full-scale cold forming process using phosphated slugs was introduced, and the necessary heavy presses installed. Since this time work has gone ahead steadily, and the company is now producing some 200,000 finished components a week in a dozen or so different designs.

Development manager, Raleigh Industries Ltd.

Components Produced

Nearly all the components which have been produced so far have been axisymmetric, and typical examples are shown in Figs. 2 and 3. In most cases these incorporate a

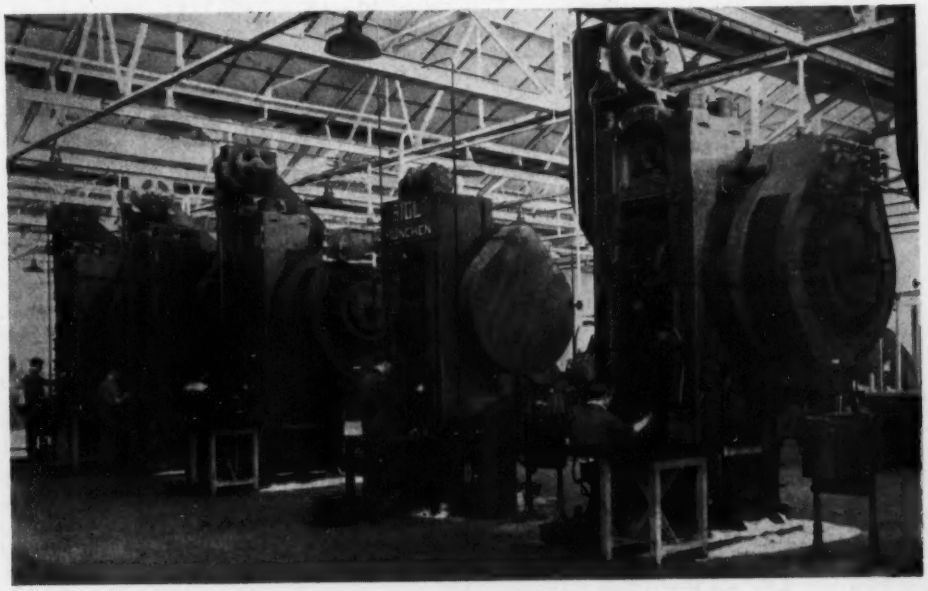
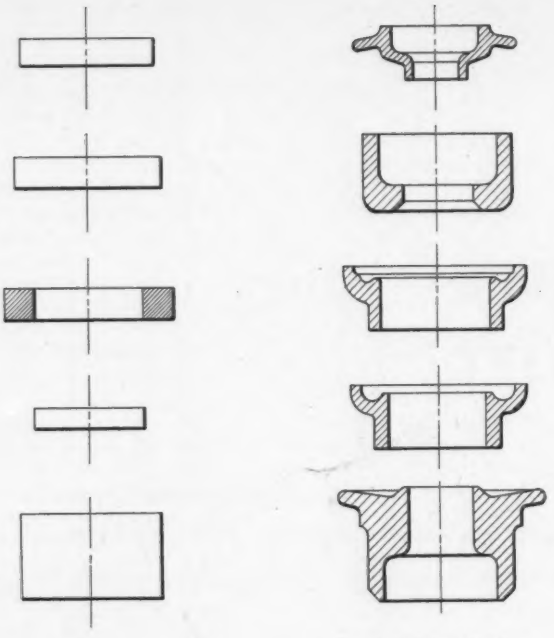
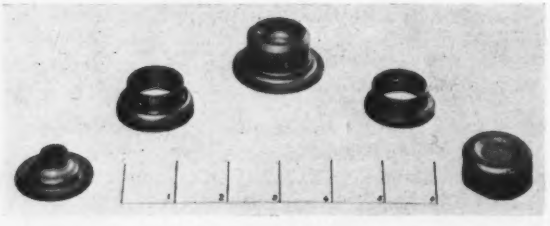


Fig. 1. Line of cold-forming presses at Raleigh Industries' works in Nottingham.





Figs. 2 and 3. Typical cold-formed components.

ball-track which has to be case-hardened. This has led to difficulties, since the steels usually recommended for cold-forming are fully aluminium killed and do not harden normally. Case-hardened components are thus formed from a silicon-killed material having a restricted manganese content, which enables a good case to be formed while the cold-working qualities are such as to give a reasonable tool life.

The company's aim has been to produce components which require no machining at all after cold forming, but in some cases a trimming operation is necessary. This of course eats into the cost savings, owing to the extra handling and the slower times on chucking automatic lathes compared with bar automatics. If a considerable amount of machining is inevitable then it is frequently worthwhile to consider the alternative of making the part by automatic hot-forming methods, which give very accurate components at rates up to 100 per minute.

When a sequence of operations has been worked out and trial runs of at least 10,000 pieces have been completed, the finished cold-formed part is offered to: Inspection for dimensional check; Laboratory for hardening and structural examination; Product Testing to check its behaviour in service; and Production to ensure that any necessary machining can be carried out. When all these departments are satisfied, then Design are invited to release the component for manufacture by the new method.

It will be appreciated that this takes time—in some cases months—before all difficulties are overcome and everyone is happy.

Production of Slugs

Slugs or blanks are produced in two main ways, depending on the nature of the component—if this has a comparatively high diameter-to-length ratio, then the slugs are made by blanking out of hot rolled and pickled strip. They may be circular, or square with cropped corners which gives rather better utilisation of material.

In many cases a washer-shaped blank is required, and in this case it is important to use the centre piercing either for another cold-formed part or for some other purpose if the process is to be truly economical.

Where a component requiring a slug has a low diameter-to-length ratio, it is usually cropped from black bar, after which it is sized to square up the ends and produce a truly cylindrical pre-form.

Before being cold formed the slugs are annealed at 1,050 deg. C., and then phosphated and lubricated.

Phosphating and Bonderlubing

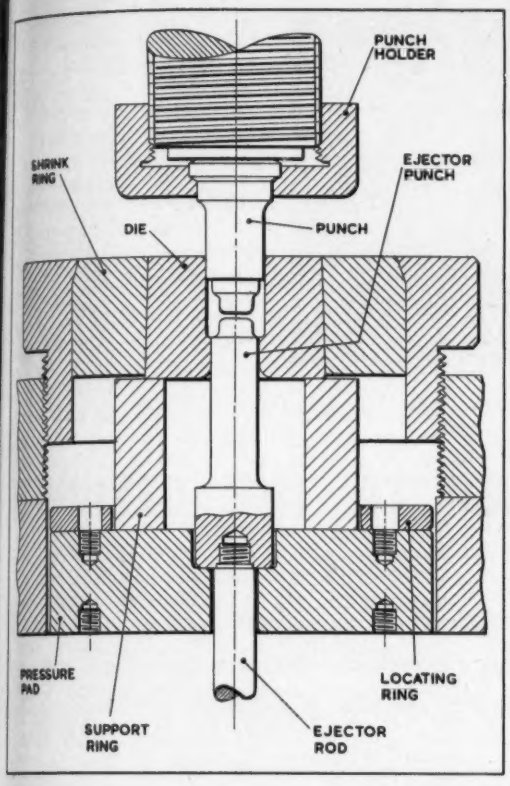
Phosphating is carried out in a Hockley Chemical Co. automatic transfer plant having twenty-five tipping buckets operating on a 2-min. time cycle. Each bucket can accommodate 40 lb. of components, and the maximum output is 1,200 lb. per hour. Pyrene Bonderite 75X solution is used to effect the phosphating, and this is followed by a bonderlube (stearate soap) treatment. The coating thickness specified varies with different components according to the amount of deformation which they undergo. Too thin a coating causes pick-up and heavy tool loading, whereas too heavy a coating may cause a build-up of the coating on the extrusion tools leading to loss of clearance and eventual failure. The coating weights used vary from 700 to 1,200 mgm./sq. ft., and the composition of the bath is controlled very carefully to ensure the consistency of coating, which is essential for good results.

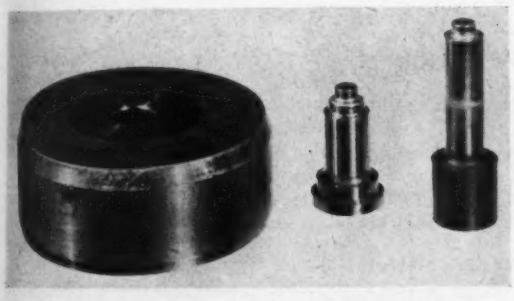
Presses

The main work horses are Craig and Donald 400-ton knuckle joint presses having a stroke of 5 in. and an output of about thirty components per minute. German Sigl presses of 400-ton capacity generally similar to the Craig and Donald presses are also used. Some of these presses can be seen in the heading illustration. These have all proved very reliable, and have given excellent service.

Tooling

A typical set-up is shown in Figs. 4 and 5. Both punches and dies are usually made in carbon-chrome steel such as Hall and Pickles Vital X hardened to about 60 Rockwell C and highly polished. The punches are usually chromium plated to a thickness of about 0·001 in. on their working surfaces after grinding, to improve their wear resistance. There is unfortunately no particular magic which can be used to ensure long tool life, but the obvious things such as sound tool steel, correct hardening, highly polished surface finish, and careful design of steps and other stress raisers are all of vital importance. Most of the troubles encountered are with punches and ejectors failing due to deficiencies in one or more of the above respects, or sometimes because the loading is just too much for the material to withstand, in which case the only solution is a design change—or a lot of spare punches! Typical punch failures are shown in Fig. 6.





Figs. 4 and 5. Cold-forming tool set, showing *(left to right)* die, punch, and ejector.

Fig. 6. Typical punch failures.

Feed Mechanism

The slugs are loaded into a vertical tube, and then then fed forward by means of a pusher into tongued slides which cause the slug to move downward progressively into the die opening. The machinism is actuated by a cam on the backshaft of the press. The completed component is then ejected and blown by an air jet down a chute at the rear of the press.

Much useful work has been done at N.E.L., P.E.R.A., R.O.F. at Birtley, and elsewhere in coming to an understanding of the basic principles of the cold deformation process, and many excellent reports have been issued. There is even a textbook on the subject (*Fliesspressen von Stahl*, by H. D. Feldmann, Berlin, 1959), but study of literature alone will not, except in the very simplest "classical" extrusions, enable quantity production of components to be achieved. This, as was emphasised by Mr. R. E. Okell (Forgings & Presswork Ltd.) at the recent Sheffield Conference, and subsequently by Dr. H. D. Feldmann (Cold Forging Ltd.), needs an experienced team and considerable development work.

One can attempt to short-circuit this need by buying, begging, borrowing or stealing the necessary experience, and new entrants to the field may have to consider all methods if quick results are required.

Economics

No general statement can be made on the economies which can be expected through introducing the cold-forming process, but for any given components it is quite easy to compare the cost of manufacture by existing and cold-forming methods, except for one thing—this is very important and is, of course, tool life. As experience is gained one becomes more confident in setting limits to the probable life of any given set of tools, and Raleigh Industries have achieved lives of 250,000 components on some punches without any trouble. As the designers, laboratory, toolroom, hardening shop and development engineers gain knowledge, the tool life will in general improve to an acceptable figure, but it is at present not easily predictable by the inexperienced.

Components which can be sheared from bar with only the loss of a small centre piercing, and no or few intermediate anneals and phosphate treatments, will show large savings. Those blanked from strip in annulus form will prove less favourable, especially if the centre piercing cannot be used. (Round wire butt-welded into a torus might be an acceptable alternative for some applications). Having to machine on a chucking automatic lathe after cold-forming may be uneconomic compared with machining the part from bar on a multi-spindle automatic, unless there are large material savings.

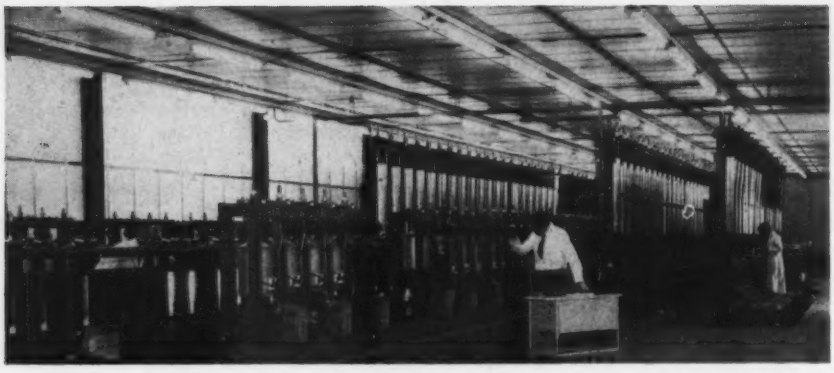
Small runs are usually uneconomical, and it wise to seek rates of production of at least 10,000 components per week before considering making them by this technique.

Conclusions

The cold-forming technique is capable of effecting economies in the production of certain parts but not all, and each case should be treated on its merits. The advice of someone already producing components in quantity should be sought first, in order to make sure that it is at least likely that the component can be produced.

It is not fair or wise to expect a presswork expert to become, over-night, an authority on cold-forming, and a company must be prepared to do considerable development work in order to produce satisfactory results.

The author thanks his colleagues Mr. A. White and Mr. D. S. Wilson, who pioneered the technique at Raleigh, for their help in the preparation of this article, and also the directors of Raleigh Industries Ltd. for their permission to publish it.



Part of the Electrical Research Association's new creep laboratory.

IMPORTANCE OF CREEP TO THE DESIGNER

The modern equipment in the new E.R.A. creep laboratory will enable long-term research on steels to be carried out, as an aid in the design and selection of materials for power stations

by Dr. A. CHITTY and
W. H. DEVENISH

WHEN a steel is subjected to tensile stress at temperature for long periods of time it increases in length. This slow elongation is known as creep, and is illustrated in Fig. 1. All creep curves have this same general character, though certain portions may be accentuated or minimized under some circumstances. Important among these are extremes of temperature or load and structural instability. Thus, at a relatively low stress and temperature creep may cease, for practical purposes, although it may be argued theoretically that this is only apparent, owing to insufficient sensitivity of measurement. At a relatively high temperature and stress, creep tests may show only an accelerating rate from the start.

The effect of structural instability, which includes phase transformation, recrystallisation and grain growth, is very important, and is the primary reason for making so many measurements of creep characteristics. These effects are very difficult to forecast with any accuracy, and must be determined experimentally.

In order to determine the creep characteristics of a particular steel it is necessary to determine curves of the type shown in Fig. 1 at a number of different temperatures and stresses. Such tests can be made by using a special tensile machine which permits the specimen to be held in a heated chamber for the duration of the test. A steady load is kept on the specimen, and the elongation of the test-piece is measured at regular intervals.

In many cases, such as with steampipes, only the rupture properties of the steel are required, and under these conditions no measurements of elongation are made under test; only the time to cause rupture of the specimen at a particular stress and temperature is recorded.

Design Criteria

Electricity generating stations operate for upwards of twenty years, and the designer of the high-temperature components requires a knowledge of the creep and rupture properties of the steel over this period of time. Thus, most components are designed on a life of 100,000 hours.

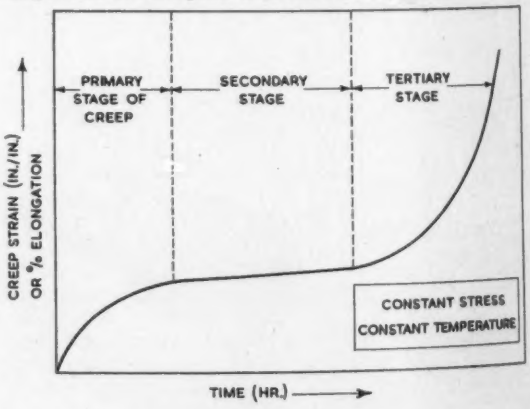


Fig. 1. Typical creep curve.

The criterion used by the turbine designer is the time taken for components such as rotors, turbine casings or blades, to creep a specific amount. The data required are shown on the type of graph given in Fig. 2. These curves are constructed by extracting co-ordinates from the creep curve of strain against time, for constant stress and temperature shown in Fig. 1.

The design of steampipes and superheater tubes is based on the maximum stress that can be applied without causing rupture in 100,000 hours.

In the laboratory, measurements are made of the time to rupture of specimens from these components at specific stresses and temperatures. The results are plotted in the form shown in Fig. 3. The designer then selects the temperature to which the component will be subjected, and reads off the maximum stress which the steel will withstand after a time of 100,000 hours.

All the foregoing determinations of properties of a steel for optimum design conditions are made on one cast, and are therefore accurate for only this cast. However, it can be shown that within a specification for a steel there is a cast to cast variation in the creep and rupture properties due to differences in manufacture. Designs based on data from a single cast may therefore be erroneous, and the designer then requires a knowledge of the magnitude of the variations in properties likely to be encountered.

To measure this "scatter" in rupture properties, specimens from a number of different casts of steel are tested in a multi-rupture machine at the same temperature and stress. Fig. 4 shows typical results of such tests. It should be noted that the width of this typical scatter band is very wide, and a design stress at 100,000 hours based on the upper part of the band would be considerably higher than that based on the lower portion of the band. The design would be based on the properties given by the lower part of the band.

Work During the Earlier Years leading to the Establishment of the New Laboratory

When the Electrical Research Association was formed, just over forty years ago, one of the seven committees set up to control the work of the Association was responsible for turbine blading material. This work then led to tests on other high-temperature components of steam power plant.

Work was originally financed at the National Physical Laboratory where, in due course, a creep-testing laboratory was built to house forty high-accuracy creep-testing machines —this was at that time considered to be a very large and up-to-date installation. Carbon steel was examined first, and then 0·5% molybdenum steel, followed by a variety of other low alloy steels.

At first it was hoped that a short-time test could be developed, a view which was held in the U.S.A. and in Europe, where 1,000-hour tests were expected to give all the information needed. The Germans have within the last few years proved to their own satisfaction that their short-time tests are insufficient and may even be misleading, and the E.R.A. 30,000-40,000 hours or more duration test is recognised as the only reliable method.

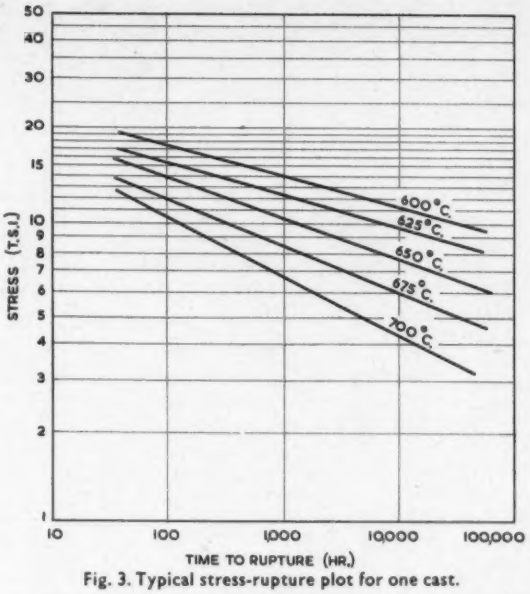


Fig. 3. Typical stress-rupture plot for one cast.

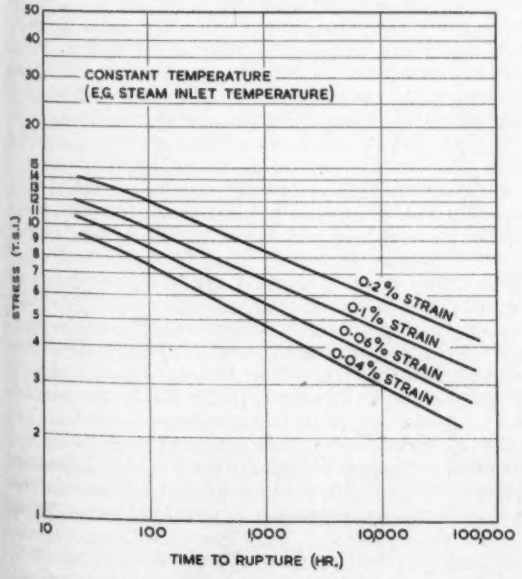


Fig. 2. Typical log stress/log time plot for specific strain at constant temperature for one cast.

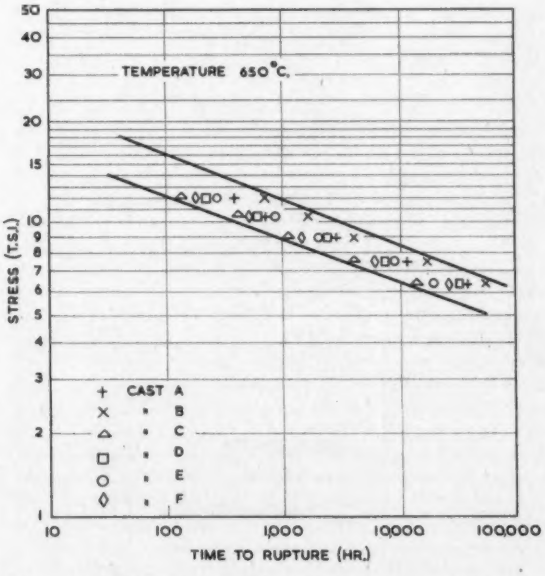


Fig. 4. Typical plot of stress rupture scatter band for a number of casts of steel of the same nominal specification.

The recognition that it is essential to examine several samples of any one type of steel has increased the number of specimens to be tested and, coupled with the increase in the number of special creep-resisting alloys and the higher temperatures required, led to a conference in 1957 between the N.P.L., the E.R.A. and representatives of industry, all of whom were well-informed on the problems of creep properties of steel.

At this meeting it was decided that the hundred or so machines available at the N.P.L. and E.R.A. needed to be supplemented by another 500 test points. This was thought too ambitious a project, and an immediate plan for 150 test points with provision for another 250 later was proposed. The E.R.A. therefore made plans to build a new laboratory in the grounds of the existing laboratory at Leatherhead, and when this was officially opened recently it provided 700 test points with sufficient space to increase this number to 1,000 should that be found necessary.

The rapid building and equipping of this laboratory was possible through financial support by a number of interested industrial organisations, including: the Central Electricity Generating Board; steel makers (through the British Iron and Steel Research Association); turbine makers; pipe makers; and the Water-Tube Boilermakers Association. The D.S.I.R. also made an important contribution.

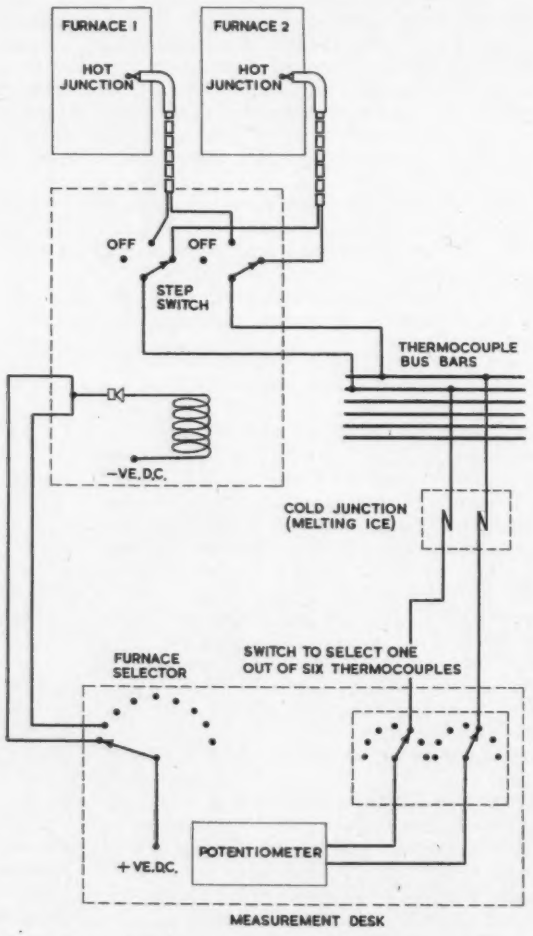


Fig. 5. Specimen temperature measurement. Circuit showing selection and measurement of one thermocouple. The system is capable of measuring six thermocouples from each of a hundred furnaces.

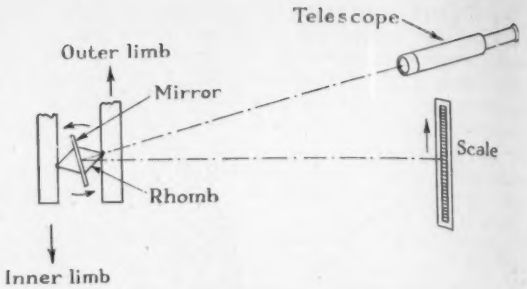


Fig. 6. Optical method for measurement of strain.

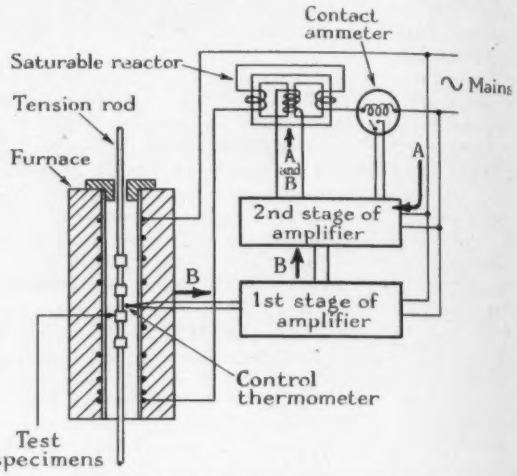


Fig. 7. Method of specimen temperature control.

Equipment of the New Laboratory

As has been stated, turbine designers work on the basis of 0·1% creep strain in 100,000 hours, and creep tests must be made in which small creep extensions are measured accurately. The fifty creep machines installed are therefore fitted with optical extensometers of a type developed by the N.P.L., in which two pairs of limbs are fitted to the specimen, one to the top and the other to the bottom. As the specimen elongates, the relative movement of these limbs rotates a rhomb supported between them; a small mirror is attached to the rhomb. The angular displacement of this mirror is proportional to the elongation of the specimen under the tensile stress, which is applied by means of a single lever arm system. The reading of elongation is made by means of a telescope and scale which are mounted a suitable distance away from the machine. Fig. 6 shows the basic details of this arrangement.

The design of this machine is one which has been in use for some years, whereas the design of the fifty rupture machines, in which ten specimens may be tested simultaneously, represents an entirely new approach to such testing, and is the factor which has enabled the number of test points to be increased from 150 to 700. In these machines ten specimens are joined in series by split couplings, and tested in a furnace 50 in. long. A string of specimens with thermocouple leads attached is shown in Fig. 8. The large extension which occurs when a number of specimens in series creep is taken up automatically by a motor-driven worm and wheel on each machine.

Another fifty dual-purpose machines installed have 20-in. furnaces instead of 50-in. furnaces. These can be used for rupture testing three specimens in series or for creep testing

larger specimens using dial gauge extensometers, which have a lower sensitivity than the optical type.

One 15-ton creep machine has been installed for testing specimens from the full wall thickness of steampipes, and eleven rigs have been included for tests on tubes stressed by internal steam pressure while at high temperature.

The furnace temperatures are of the order of 650 deg. C., and must not deviate by more than 3 deg. C. from their correct value. Since a change of 0·4% in the voltage applied to the furnace will produce 3 deg. C. change of furnace temperature, the effect of mains voltage fluctuations must be accurately compensated. A change of ambient temperature will also affect furnace temperatures; furthermore, since ambient temperature changes are slow, they are therefore more amenable to automatic correction.

Each furnace has a control circuit (see Fig. 7) consisting of a resistance thermometer, an electronic control unit, and a saturable reactor designed to compensate for (a) fluctuations in mains voltage and (b) changes in ambient temperature.

Assuming the ambient temperature is constant, when the mains voltage fluctuates a steady furnace temperature can be maintained only if the voltage across the furnace remains constant. This is accomplished by the feedback loop *A* in Fig. 7.

The furnace temperature does however tend to follow changes in ambient temperature, and to compensate for these the unbalance voltage from a bridge circuit, one arm of which is a resistance thermometer located close to the furnace winding, is fed to the input of the electronic control unit. This circuit is shown as *B* in Fig. 7.

The ideal position for the resistance thermometer is inside the furnace tube, but these thermometers are fragile and liable to be broken when specimens rupture. For this reason the themometer is inserted through the side of the furnace so that the sensitive element rests tangentially against the furnace winding. Some doubt was felt as to whether this would be satisfactory if the winding consisted of widely-spaced turns of wire, and the furnaces are therefore wound with ribbon in closely-spaced turns.

To take care of controller failure, which would cause the furnace temperature to rise out of control, an ammeter fitted with an adjustable contact to make with another contact on the pointer is inserted in series with the furnace winding. When the contacts in the ammeter touch, the output valve in the controller receives a high negative bias which reduces the furnace current.

The test temperatures are measured with platinum/platinum-rhodium thermocouples attached to the specimens. These materials possess the most stable characteristics for the long times involved in many of the tests.

The short furnaces employ three thermocouples and the long ones five, and in order to economise on the number of wires returned to the measuring desk, the large amount of platinum, and the large number of cold junctions that would otherwise be required, a system of switching close to the thermocouples was developed. In this method, shown diagrammatically in Fig. 5, all the temperature measurements are made at a central desk. A selector on the desk actuates a switch close to the furnace which switches all the thermocouples from that furnace on to busbars of compensating wire. A second switch on the measuring desk then selects the busbar corresponding to the thermocouple to be measured. This is measured with a potentiometer. By this means only one cold junction is required from a set of busbars, and copper wire can be used between the cold junction and the measuring desk.

To facilitate the setting up of the furnaces the thermocouples can be plugged into a recording system, and measured at the furnace with a portable potentiometer.

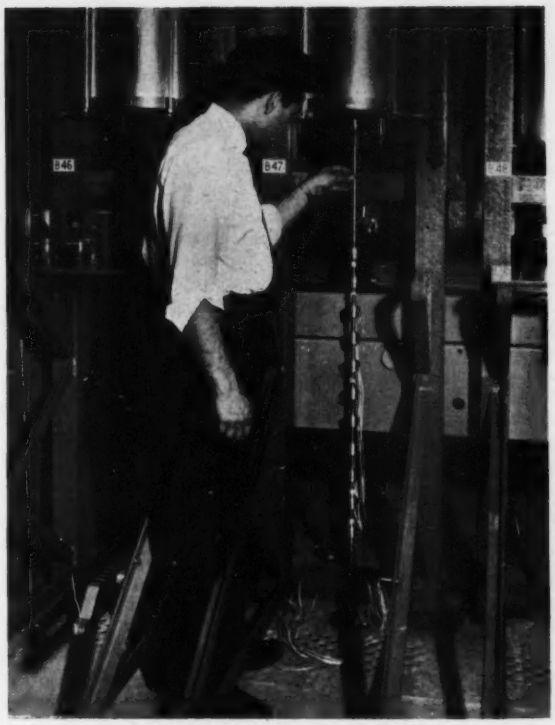


Fig. 8. Specimen chain.

Collection of Data on British Steels

Since the work on high-temperature properties of steels was first supported by the Electrical Research Association a considerable amount of data has been obtained, mainly on low alloy ferritic steels. However, although designers have always required to know the properties of steels at 100,000 hours, it is only in recent years that there has been any great effort towards obtaining actual test results at these long times. Previously designers have had to use extrapolations to times of tenfold those obtained experimentally. For these reasons, large safety factors have had to be employed in the design.

An interesting stage has now been reached in power-station design in which the comparatively low cost alloy ferritic steels are being replaced by the very expensive highly-alloyed austenitic steels owing to the higher design temperatures used. Thus, a great effort is being made in the U.K. to obtain reliable data at long times in order to be certain of the properties to be expected in these highly-alloyed steels. Not only are these steels intrinsically expensive, but also the fabrication costs are high. The capital cost of steampipes, for instance, could be greatly reduced if designers could have confidence in the experimental rupture data, which would allow them to reduce the wall section.

At the present time an effort is being made to collect data on steels of vital importance to the steam power industry by the new laboratory of the Electrical Research Association and by the steelmakers themselves through B.I.S.R.A. It is hoped that eventually a library of such data will be built up by the Creep Information Centre of the National Engineering Laboratory, and that perhaps one day designers will be supplied with accurately determined creep and stress rupture figures for a design life of 100,000 hours.

The authors have drawn freely from three contributions, by Dr. N. P. Allen, Mr. J. W. Dalton and Mr. B. Pochobradsky, to *Co-operative Electrical Research*, which is the Journal of the Electrical Research Association.

THE MISES-HENCKY CRITERION FOR YIELD

by A. ORMEROD, B.Sc., D.I.C., A.M.I.Mech.E.*

ALL engineers are familiar with the way a metal behaves in a simple tensile test; at first there is a small elastic elongation, and then when the stress reaches the yield value there is a much greater permanent elongation which may be described as plastic flow.

There is no way of calculating the yield stress of any particular material; it must be found experimentally by testing a sample. Experiments have shown that the yield stress of a ductile material in compression has the same value as the yield stress in tension. It is therefore unnecessary to test a sample in compression—the tensile test suffices.

In service a material is often required to withstand not merely a simple tensile or compressive stress; it may be stressed three dimensionally as indicated in Fig. 1. This figure shows three principal stresses p_1, p_2 and p_3 acting in the x, y and z directions respectively. The question now arises in design, at what values of p_1, p_2 and p_3 will the material yield?

What is required is a formula containing p_1, p_2 and p_3 which may be used for any possible combination of the stresses to indicate whether or not the material will yield. Needless to say such a formula cannot be derived entirely on theoretical grounds; any suggested formula must be confirmed by experimental work. The formula which is now generally accepted is known as the Mises-Hencky criterion. The reasoning which led up to the selection of this formula for experimental confirmation is quite simple. An appreciation of it helps to give concrete significance to an otherwise abstract set of symbols.

The Characteristics of Yield

The salient physical feature of yielding is a change of shape of the material. In Fig. 2 this change has been exaggerated for clarity. Fig. 2a illustrates yield in a simple tensile test; a piece of the test bar, originally a cube, has extended in the direction of the stress with compensating contraction in the transverse directions. Fig. 2b shows the distortions which occur when a cube of material yields under the action of bi-axial stress; there are elongations and contractions in the different directions according to the nature of the applied stresses.

Yield under Tri-axial Stress

Returning now to a consideration of the cube shown in Fig. 1. subjected to tri-axial stress, the question arises of how the cube will distort if the three stresses are gradually increased in due proportion until it yields? If p_1 is large compared with p_2 and p_3 the cube will yield by extending in the direction of p_1 while contracting in the other directions. If, however, the three stresses are all equal there is no reason why the material should elongate in any one direction in preference to the other directions. In fact, if the stresses are equal the material will not yield no matter how great the stresses are.

Under tensile stresses, although the material cannot yield, it may of course fracture without yielding, i.e. in a brittle fashion. It is not easy to arrange a method of applying equal tension in all directions, but near the root of a notch or "stress-raiser" the material is under tri-axial tension, and although the stresses may not be precisely equal, many materials which are ductile in a simple tension test will show a brittle fracture in a notched bar test. What is much more disturbing, such fractures occur in service.

If the stresses are compressive and all equal the material will neither yield nor fracture and, on removal of the stresses, is quite undamaged. This has been demonstrated by immersing pieces of soft material in oil and subjecting them to very high pressures: nothing happens.

Expression of Conditions for Yield

The material will yield then only if the principal stresses are unequal; or, giving this statement formal expression, if all or some of the quantities (p_1-p_2), (p_2-p_3) and (p_3-p_1) have a value. Any formula which expresses the conditions for yield may be expected to contain these quantities in some form. The appropriate sign must be given to the stresses to denote whether they are tensile or compressive. Experience has shown that a material usually yields under a set of compressive stresses of the same value as the corresponding set of tensile stresses which are required to cause yield. In other words, if the signs of the applied stresses are reversed the formula must still give the same answer. This condition would be fulfilled if the significant quantities (p_1-p_2) etc., appeared as squares—$(p_1-p_2)^2$, etc.

Experimental Selection of Formula

The next step is to take all the available results of experiments on yielding under different stress systems and to see whether they can be expressed by some symmetrical formula containing the three quantities $(p_1-p_2)^2$, $(p_2-p_3)^2$ and $(p_3-p_1)^2$. In this search it is logical to try first the simplest expressions, for example the product of the three quantities, or their sum. It is found in fact that any particular material will yield if the sum of these quantities reaches a value which is the critical value for that material.

An experiment must be made to determine this critical value. The experiment which is easiest to arrange is the standard tensile test which gives the normal yield stress f_y. Now in the tensile test at yield, $p_1=f_y$, $p_2=0$, $p_3=0$, so the critical value for the material is

$$(f_y-0)^2 + 0 + (0-f_y)^2 = 2f^2_y.$$

Yield will occur under the action of a set of stresses p_1, p_2 and p_3 when

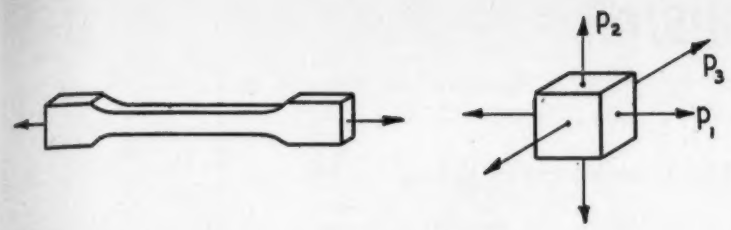
$$(p_1-p_2)^2 + (p_2-p_3)^2 + (p_3-p_1)^2 = 2f^2_y.$$

This is the Mises-Hencky criterion for yield, and it can be regarded simply as an empirical formula based on experimental data.

The Concept of Shear Strain Energy

When the criterion was first suggested it was felt that it might be more acceptable if the expression on the left-hand side of the equation could be shown to be a measure of some physical property of the material. This can be achieved by introducing the concept of "shear strain energy", which is done as follows. The general stress system shown in Fig. 1 can be regarded as the sum of the two systems shown in Fig. 3. The "volumetric" stress system applied to an elastic

* Royal Military College of Science, Shrivenham.



Figs. 1. Showing *(far left)* simple tension, and *(near left)* three-dimensional stress.

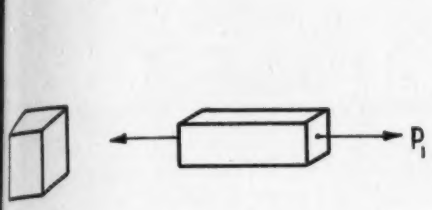
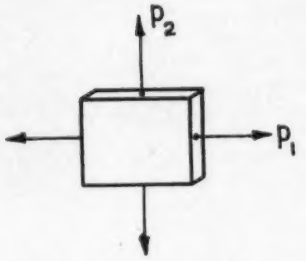


Fig. 2 (a). Yield in simple tension.



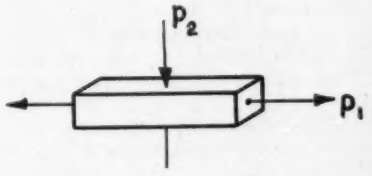


Fig. 2 (b). Yield with bi-axial stress.

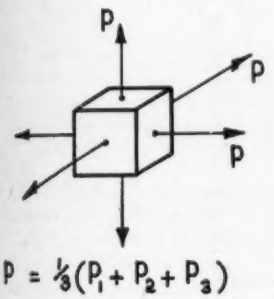


Fig. 3 (a). Volumetric stress.

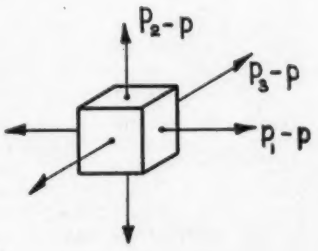


Fig. 3 (b). Pure shear stress.

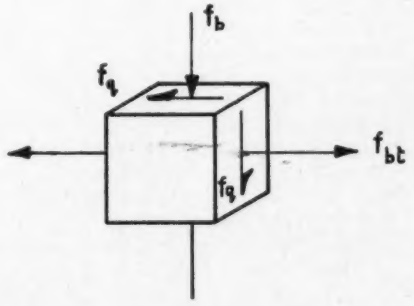


Fig. 4. Typical application of the Mises-Hencky criterion.

material causes a slight change in volume, but as the material is stressed equally in all directions there is no change of shape—a cube remains a cube. The pure shear system is characterised by the sum of the three principal stresses being zero; applied to an elastic material it causes no change of volume, but since the strains in different directions are unequal there is a change of shape.

As stresses are applied to an elastic material, work is done and is stored in the material as elastic strain energy. As the stresses p_1, p_2 and p_3 are applied the energy stored may be divided into two parts—that due to the volumetric loading, and that due to the shear loading. This second part, known as "shear strain energy", has the value

$$1/12\,C\,[(p_1-p_2)^2 + (p_2-p_3)^2 + (p_3-p_1)^2]$$

where C is the modulus of rigidity.

The yield criterion may be described by saying that an elastic material has a limited capacity for storing shear strain energy; when this limit is exceeded the material ceases to be elastic, and becomes plastic, i.e. yields. The limit of capacity is found from a simple tensile test, and is

$$2\,f^2_y\,/\,12\,C$$

Example of the Use of the Criterion

An example of the use of the criterion appears in BS 449: 1959, "The Use of Structural Steel in Building". In Part 4, Clause 14 (d), a rule is given for design to meet the conditions where steel is subjected to a tensile bending stress f_{bt}, a compressive bearing stress f_b and a shear stress f_q. The stress system specified is shown in Fig. 4. The rule given is that the system shall be reduced to an "equivalent" stress f_e; the greatest permissible value of f_e is the yield stress divided by an appropriate factor of safety.

The formula to be used is

$$f_e = \sqrt{f^2_{bt} + f^2_b + f_{bt} f_b + 3 f^2_q}$$

To apply the Mises-Hencky criterion to the stress system of Fig. 4 it must be noted that the shear strain energy due to f_{bt} and f_b is found by taking $p_1 = f_{bt}$, $p_2 = 0$, and $p_3 = -f_b$, and is $1/6\,C\,[f^2_{bt} + f^2_b + f_{bt}\,f_b]$. The shear strain energy due to f_q is $f^2_q\,/\,2\,C$; thus the total shear strain energy is

$$1/6\,C\,[f^2_{bt} + f^2_b + f_{bt}\,f_B + 3\,f^2_q]$$

which must be equated to $f^2_y/6\,C$. The Mises-Hencky criterion then takes the form

$$f_y = \sqrt{f^2_{bt} + f^2_b + f_{bt}\,f_b + 3\,f^2_q}$$

which corresponds with the formula given in the specification.

Conclusion

It must be emphasised that the Mises-Hencky criterion is a criterion for yield. If the stress system is entirely tensile there is a possibility of brittle fracture, and a yield criterion should be used only in conjunction with an over-riding criterion for fracture.

NEW IDEAS IN DESIGN

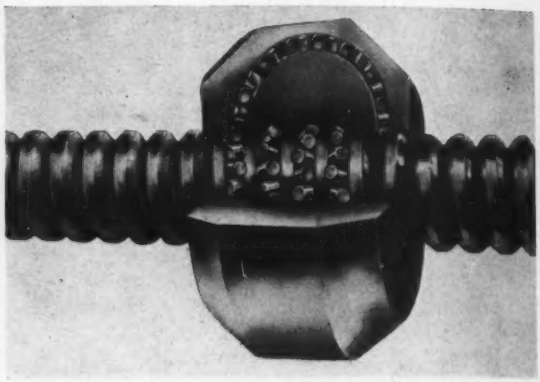
Outstanding products in current manufacture and awaiting development in the U.K.

The Crossed-roller Screw

AN anti-friction screw, introduced for the first time at the recent seventh European Machine Tool Exhibition by Societe M.O. (250 Boulevard de la Boissière, Montreuil-sous-Bois, Seine, France), is claimed to have certain advantages over recirculating screws employing balls. The screw uses alternately staggered rollers of nearly square cross-section and is said to make possible assemblies having no play.

The principal advantage that this system has over the recirculating ball type of screw is said to lie in the fact that the load capacity is greater, since line contact is made between the rollers and the flanks of the screw threads, thus avoiding brinelling or tracking. In addition, from the manufacturing standpoint, it is claimed that the screws are easy to make and measure because of their simple helicoidal shape with flat flanks.

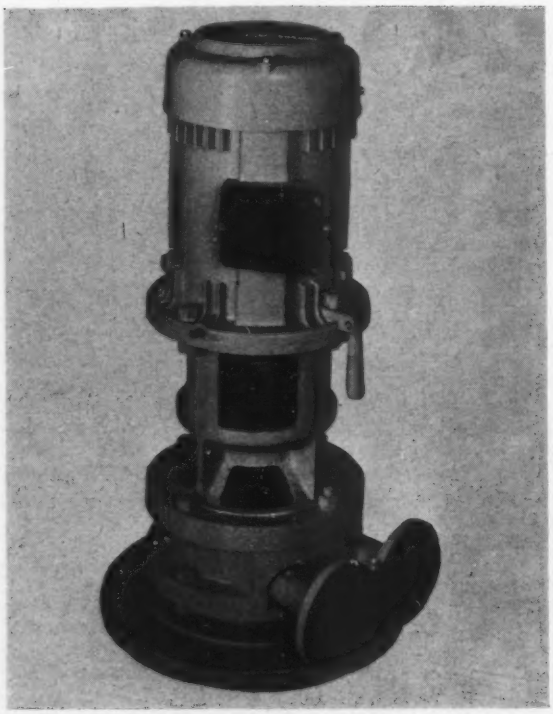
At present the Crossed-roller Screw is available in three main categories of size. For light mechanical work, screw diameters ranging from 4 to 25 mm. are available, all of these employing rollers of 1.5 mm. dia. For general mechanical applications screw diameters from 12 to 50 mm. are supplied, the rollers for these being of 3 mm. dia. For heavy-duty applications, a range of screws from 25 to 275 mm. dia. using rollers of 6, 9, 15 and 24 mm. dia. are recommended. Other sizes can be obtained on application. The load capacity for the smallest size (4 mm. dia.) is 40 kg., while for the 275 mm. dia. it is 28,000 kg.



The manufacturers state that if at the design stage it is not possible to use a screw of the right capacity, it is possible to use them in pairs or threes. Screws with pre-loaded rollers can be supplied, and also versions protected against the ingress of dust. Adjustable backlash is also available to special order.

The screws and nuts are heat-treated to Rockwell 63-65, but special steels can be used if required. The mechanical efficiency of the crossed-roller screw is said to be 98%.

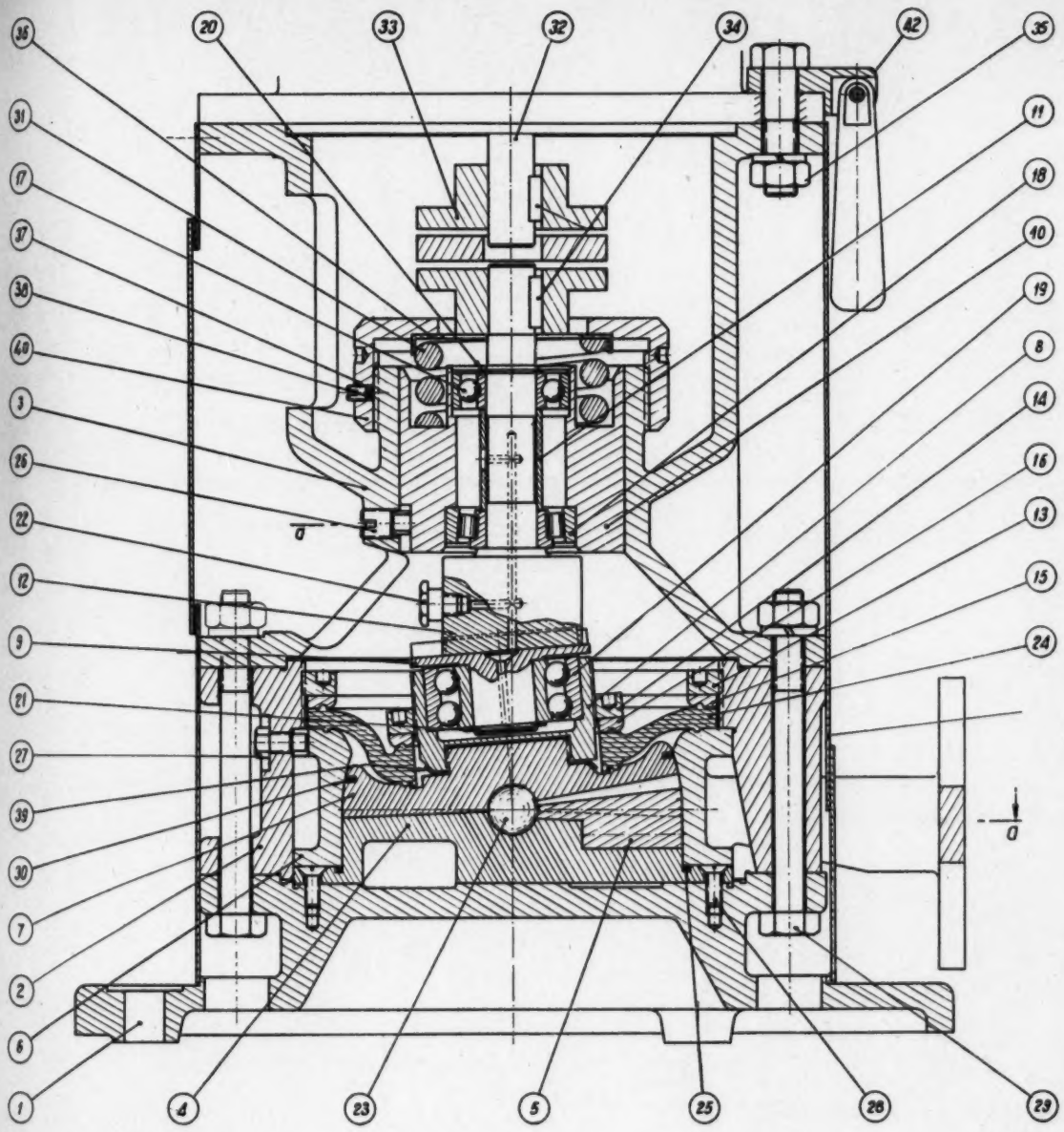
Since recirculating ball screws have already found wide application in motor vehicles and machine tools, the added advantages of this new development should make it readily acceptable in these and other spheres.



An Ingenious Swash-diaphragm Pump

THE Type 2C pump, recently introduced in France by Société Girator of Asnières, Seine, has been developed for handling highly-corrosive liquids. To achieve complete sealing of the pump chamber from the rotating parts, an interesting variant of the swash-plate principle has been produced.

The pump is composed of three main parts: the piston *7*, the body *6*, and the rolling platform *4*. The piston is conical in shape on its lower surface, the upper side being part of a hemisphere, and it is caused to oscillate about a single ball *23* by the offset end of the drive shaft, which transmits its motion through a double row ball-bearing. The outer race of this bearing is held in a component *8*, the lower side of which is bored to receive a spigot turned on the upper side of the piston *7*. Rotation of the drive shaft causes the piston to trace a conical path about the centre of the bearing sphere *23*, the conical lower surface of the piston rolling around the lower fixed rolling platform. A small wedge piece *5* let into the rolling platform and positioned between the inlet and outlet branches determines the beginning and end of the pumping stroke. The slightly raised ridge in the



rolling platform produced by this wedge piece fits a corresponding cut-out in the lower conical surface of the piston.

Complete sealing of the pump chamber from the bearings, etc., is achieved by means of a flexible diaphragm *24*. This can be made of butyl or natural rubber, Hypalon, neoprene, Viton or a number of other alternative materials, according to the requirements of the user. The manner in which the diaphragm is held can be seen in the accompanying drawing.

The pump is self-compensating for wear. This is achieved by means of a sliding bearing holder *10* which carries the main drive shaft bearings, being urged forward by the short compression spring *36*. The pressure exerted by this spring is adjusted by the screwed locking ring *40*.

Each revolution of the piston displaces a volume of liquid corresponding the volume left between the two conical surfaces and the part-hemisphere of the pump chamber. The formula for the volume delivered per revolution is

$$V = 4{\cdot}1888\ R\ 3 \sin \phi$$

where R = Radius of piston and ϕ = Cone angle.

The 2C pump can be supplied with the body in Ni-Resist or 18/8/3 stainless steel. The ball *23* can be in glass or stainless steel. The piston radius is $2\frac{1}{8}$ in., the cone angle 2°, and the diameter of the branches 1 in. The base diameter is $13\frac{1}{4}$ in., and the height of the pump (with motor) 24 in.

The pump is self-priming, and can deliver approximately 28 cu. ft./hr. at 43 p.s.i. It is very quiet in operation, and there is only central greasing nipple accessible from the exterior.

Interested manufacturers are asked to contact *E.M. & D.* for further details.

EMD 8227 for further information

INDUSTRY WELCOMES THE NEW TECALEMIT RIBBON FILTER ELEMENTS

Setting a fresh standard of high efficiency filtration for

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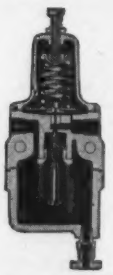
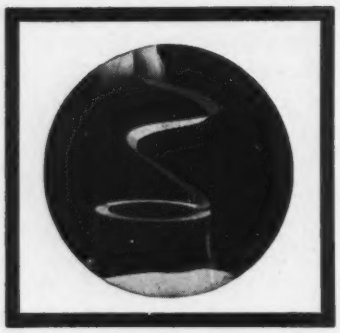
Tecalemit Ribbon Filter Element is used in the series 67 combination Filter Regulator, manufactured by Fisher Governor Company Limited of Rochester. In such an application, the paper ribbon filter allows air to flow freely and provide adequate filtration, and water separation. A Tecalemit ribbon filter is sufficiently robust to withstand pressure drops well in excess of normal working conditions.





Tecalemit Ribbon Filter Elements

Simple construction—Low cost—High flow rate—Easy to clean

The elements are formed to resin impregnated cellulose ribbon, wound helically and electrically fused into an open-ended cylinder. Innumerable microscopic orifices between the ribbons allow a very high flow rate, while retaining impurities on the outside or inside surfaces, according to direction of flow. The standard range of diameters (in any length) covers most applications, and no other filtration material can so readily be adapted to individual requirements for filters, strainers, breathers or separators. Never before has such fine filtration been possible at such low cost and with such flexibility in use.

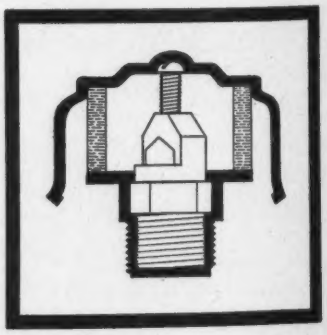
Tecalemit Ribbon Elements filter to maximum purity

Tecalemit Air Breather Filters

(Incorporating Tecalemit Ribbon Filter Elements)

Cheapest—most efficient—cleanest to service Tecalemit Breathers act as ventilators to provide a free flow of clean air to hydraulic fluid, fuel and oil reservoirs. They give positive protection from airborne contamination to tanks, pumps, valves, cylinder and other engine components. Of the standard types, two are breathers with screwed bodies, and the third is a combined clip-on assembly of breather and filter cap. All are fitted with Tecalemit Ribbon Filter Elements.

Tecalemit Breathers provide pure air cheaply and efficiently



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T. 388

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

New High-temperature Epoxy Casting Compound

A new, long pot life, epoxy casting compound has been developed by Minneapolis Honeywell Regulator Co. for high temperature use (204 deg. C. continuous) in potting and encapsulating electrical and electronic components and devices. It is based on a di-epoxide derived from peracetic acid. The casting compound features a low, stable coefficient of thermal expansion over a wide temperature range. It also possesses a room temperature pot life of several days, which is a decided advantage for small production lots, and good dimensional stability at elevated temperatures.

The coefficient of thermal expansion for this material is lower than that of any known commercially available epoxy system. The curve is characterised by a broad relatively flat region between 80 and 180 deg. C. where it rises very slowly with increasing temperature. It parallels the curves for aluminium and steel in this temperature range where their C.T.E. increase is also very gradual with temperature. By using this new material as a casting compound around or within metal shapes, less stress will be produced in the epoxy than with conventional epoxies whose curves rise rather sharply, especially above 100 deg. C.

Differential expansion in this formulation is nearly zero between 80 and 180 deg. C. This low, non-changing coefficient of thermal expansion means in practice that metal-to-plastic bonds can be designed with less chance of stresses being set up between the plastic and metal over a rather wide temperature range.

Adhesive strength was determined at room temperature, 163, 204 and 232 deg. C. on steel-to-steel tensile shear strips. At room temperature there was an average strength of 3,000 p.s.i.; after 1 hr. at 163 deg., 2,700; after 1 hr. at 204 deg., 2,600; after 1 hr. at 232 deg., 2,400 p.s.i.

An advantage of this material over a carbonate or silica filled epoxy is its handling characteristics. It is quite pourable at room temperature and has a pot life of approximately five days at room temperature and 10 hr. at 76 deg. C.

The agents for this material in the U.K. are Honeywell Controls Ltd.

New Design of Turbulence Chamber

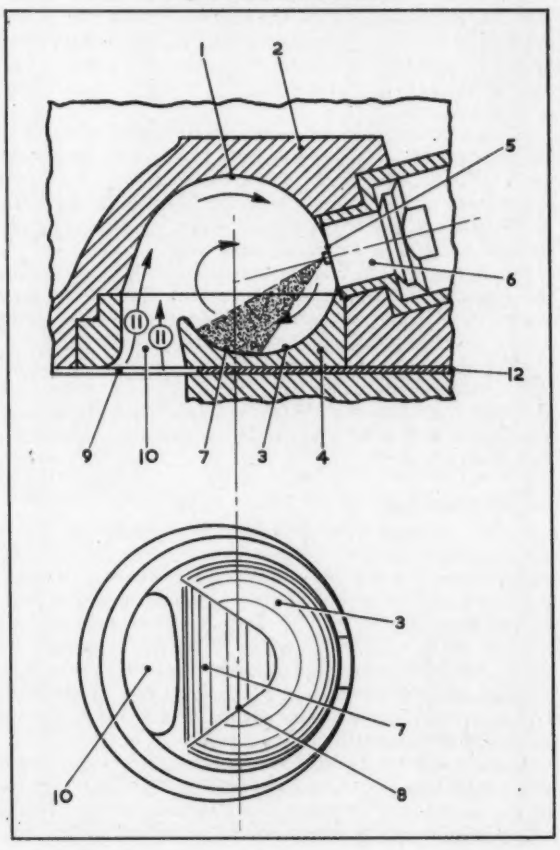
In a new high-performance turbulence chamber developed by the Hispano-Suiza company, the shape is generated by two hemispheres of different radius, one being formed by a cavity *1* in the combustion head *2*, and the other *3* by a similar cavity in a lower element *4*. This lower element *4* has, in addition to its spherical section, a cylindrical section *7* whose limit is shown in the lower view in Fig. 1 by the boundary line *8*. The turbulence chamber connects with the cylinder *9* via a transfer channel *10*.

The axis of the injector is directed at the top of the transfer channel, and passes substantially through the centre of the chamber. During compression, the air sweeps through the upper part of the chamber formed by the hemisphere of the largest radius *1*, then reaches the lower element containing the smaller radius, and as a result is accelerated and forced towards the centre of the chamber. Moreover the cylindrical part *7* spreads the gas along the sides of the peak of the transfer channel. The result of this arrangement is to "draw" on the air *11* to obtain maximum filling of the chamber. At the same time, the mixture being continuously forced towards the centre of the chamber and towards the lower element *4* does not come into contact with the cold upper wall *1*.

At the beginning of injection, the jet is projected (as shown in Fig. 1) onto the walls *3* and *7* of the lower element by the violent eddies arising from the extreme turbulence of the gas; thus it is possible to obtain a homogeneous mixture of air and fuel. The transfer channel is extremely short, and is aerodynamically shaped to match the high air and gas velocities; as a result the loss of charge is negligible, even at the highest operating rates.

It is imperative that the lower element *4* of the combustion chamber should be centred in relation to the upper part of the chamber. It is equally important that this lower element should be fixed against rotation. One of the principles of this turbulence chamber implies the maintenance of a high temperature in the lower element *4*. This is insulated from the cylinder block by a special joint *12* of low thermal conductivity.

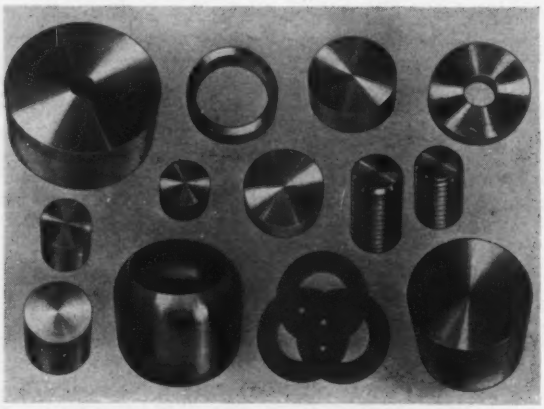
Fig. 1. Section and plan views of the Hispano-Suiza diesel-engine turbulence chamber.



New Tungsten Alloy

Kennertium Grade W-10 tungsten alloy, made by Kennametal Inc., Penn., U.S.A., is a free-machining composition when carbide tooling is employed, and is suitable for those applications where heavy metals are being most generally used, e.g. radioactive shielding, balancing, and providing high rotational inertia.

The material is available in virtually any configuration. Solid sections up to 10 in. dia. by 20 in. long can be explosive pressed, and parts machined therefrom. Cold press quality material can be provided in short lengths in the form of thin



rings up to 14 in. o.d., and hot pressed sections can be processed up to 25 in. o.d. These two grades can also be supplied as discs ¼ in. thick and up to 14 in. dia.; slabs ¼ in. thick and 14 in. square; and brick or arched brick shapes 4 in. square by 8 in. long. Kennertium can be readily machined, drilled and tapped with carbide tools, as the smooth surface finish obtained generally eliminates the need for grinding. High-speed-steel surface-treated drills may be used if carbide tools are not available.

With grinding, the best results are obtained by using an aluminium oxide or silicon carbide wheel of medium hardness, with a vitrified bond. Milling speeds and feeds normally used for grey cast iron are generally suitable. If a coolant is required for any of the foregoing operations, one part of soluble oil to twenty parts of water may be used.

While Kennertium W-10 cannot be joined by conventional welding methods, it can be fastened to itself or to other metals by silver or copper brazing, soldering, press or shrink fitting, or mechanical attachment—including threading.

Typical properties include a density of 0·61 lb./cu. in., and a tensile strength of 100,000 to 135,000 p.s.i. with a yield strength (0·2% offset) of 75,000 to 90,000 p.s.i. Modulus of elasticity is 45,000,000 p.s.i., and Charpy impact (unnotched specimen) is 50 ft. lb.

Graft Cellulose

A new industrial raw material resulting from the highly uniform grafting of an organic compound to the cellulose polymer and representing a significant advance in cellulose chemistry was revealed recently by Eastern Research Division of Rayonier Inc., of New York. Trade-named Ethylose, the new material—an outgrowth of the chemical cellulose producer's graft polymer programme—is seen by company officials as only the first in a whole family of modified celluloses in which various chemicals and polymers are grafted on to a basic cellulose backbone.

The company is hopeful that the new material will broaden and further diversify the uses for cellulose. Potential markets of special interest include coated papers, textiles, paints, ceramics and foods.

Ethylose is a high-quality, purified wood cellulose modified or grafted with a small amount of ethylene oxide to alter its behaviour characteristics. It differs from viscose in that it is stable in the small pellet form in which it is prepared as well as in solution. It can be shipped for long distances or stored for long periods without deterioration and without the need and expense of handling large quantities of water and other solvents.

Up to 8-12% Ethylose can be dissolved in a solution of 5% or more of a sodium hydroxide (NaOH) concentration. Other bases such as potassium hydroxide and lithium hydroxide can also be used. The Rayonier graft cellulose is also soluble in the common cellulosic solvents such as cuprammonium hydroxide, cupriethylene diamine, ammonium thiocyanate, sodium ferric tartrate, Cadoxen, etc. Ethylose swells slightly in quarternary ammonium compounds and is insoluble in nearly all organic solvents, as well as water.

Ethylose solutions can be adjusted to proper solids-viscosity ranges for coating, tub sizing or surface spraying. It can be regenerated by alkali removal or heat followed by washing. The particular method selected will depend on the process and end-use requirements. Neutralisation can be accomplished by acid-salt solutions such as 10% H_2SO_4 and 15% Na_2SO_4, or by acid alone. Acid-salt solutions of a dehydrating nature regenerate a product with higher density, lower gel swelling and best physical strength. Temperatures in the range of 40-60 deg. C. are preferred.

Stress Lacquer

Brafa elongation lacquer, made by Hottinger Messtechnik GmbH, of Germany, when applied in a thin film, follows the elongation of a test piece only up to a certain level. If this level is exceeded, the lacquer breaks into multiple fine hair cracks at right angles to the main strain direction. From the resulting strain picture it is possible to use strain gauges to obtain quantitative stress values.

This lacquer is characterised by its ease of use, low cost and high sensitivity; elongation lines can be set up in the lacquer in steel parts at a level as low as approx. 2 kg./sq. mm. To make the cracks easier to recognise and photograph, the lacquer is coloured.

The lacquer is supplied in three different types which are distinguished by the temperature at which the test will be effected: type A, for a loading temperature of 30 deg. C. (high summer temperature); type B, for a loading temperature of 20 deg. C (for indoors investigation); and type C, for a loading temperature of 10 deg. C. (winter temperature).

The part to be investigated is first cleaned mechanically and then degreased with a solvent. The lacquer rods should be heated to about 30 deg. C. to ensure that the lacquer does not flake off at application. The test must be ready for operation so that the part can be loaded directly after cooling.

The part must be preheated to about 100-140 deg. C., which is the melting point of the lacquer. The correct temperature can be tested by dabbing the part with the stick of lacquer, which would then melt to a viscous liquid and adhere to the part. The thickness of the coating should be 200 to 300 microns, and should be applied as uniformly as possible.

After lacquering the part is allowed to cool, and it should be noted that the correct loading temperature is important.

The lacquer cracks first become visible to the eye through the refraction of light, therefore the part should be illuminated obliquely and considered in the direction of the light; the cracks running at right angles to the light then show up as bright lines. To be able to see all the cracks, the light and the view point must be frequently changed.

What helps

What saves a push-rod from getting the push? Or a piston from blowing its top? What helps a liner to toe the line; and the governor to know when to stop?
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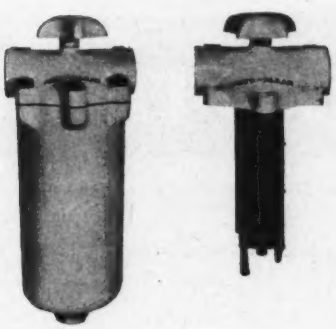
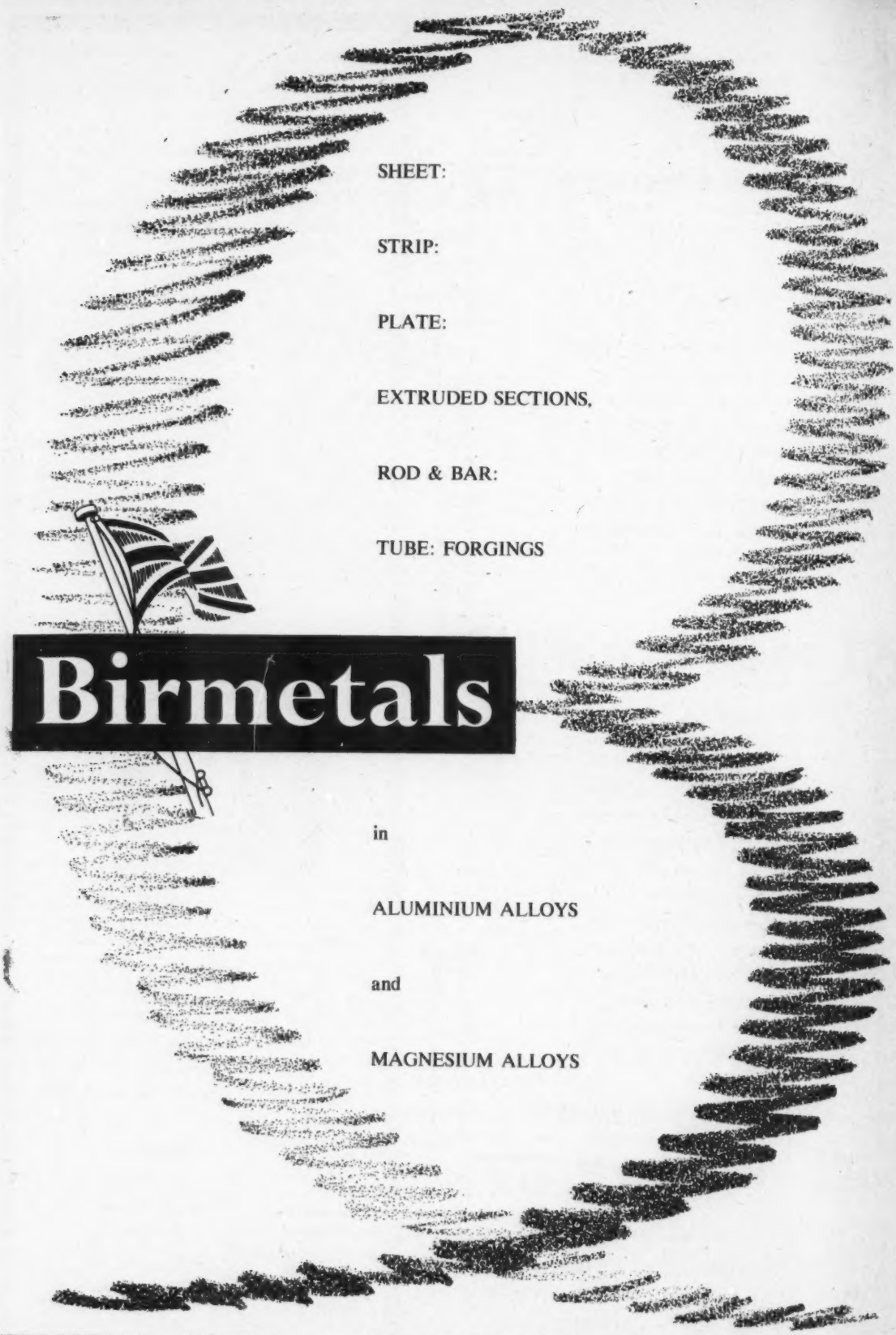
This Auto-Klean filter, type 15KA, is recommended for service with all kinds of oils. It can also be used for distillates, water, chemicals, beverages, food products, paints, resins, greases, pulp, and industrial liquids of every kind. It operates on the edge filtration principle using an all metal plate-type element. A magnetic insert is incorporated in the sump drain plug to give additional protection against ferrous particles.

. . . This self-cleaning AUTO-KLEAN filter



Cleaning is simple — by one complete turn of the handle attached to the element spindle. It is accomplished without interrupting the flow of liquid. Maximum working pressure is 125 p.s.i. Defined meshes range from 0.0015" to 0.010". Maximum flow rate for any conditions — 4,000 gallons per hour. Full details will be sent on request.

A range of filters is also available for varying applications and flows up to 150,000 gallons per hour.



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SPECIFICATIONS FOR STEEL CASTINGS

Engineering Materials and Design
DATA SHEET No. 72

The following tables are based on British Standard Specifications for steel castings, and users of steel castings are recommended to consult them whenever practicable. Although the properties shown on the left-hand side of the selection guide are present to some degree in all steels, each specification listed on the right-hand side of the guide has as a particular feature the property shown on the left-hand side.

Selection Guide

Properties	British Standards
Abrasion Resistance	1457 1956 1760
Corrosion Resistance	1632 1631 1630 1504–846 –845 –821 –801 –713
Creep Resistance	1398 1631 1463 1462 1461 1504–629 –625 –623 –622 –240
Ductility	1617 592A 1504–101 A and B
General Engineering Properties ..	592 1504–101
Hardness	1956 1760
Heat Resistance	1648
High Tensile Strength	1459 1458 1504–629 –625 –623
High Yield Stress	1459 1458 1504–629 –625
Machinability	592 1504–101 A and B
Magnetic Permeability	1617
Notch Ductility (Izod)	1456 1458 1504–503 –621
Pressure Tightness	1504–161
Structural Strength	1459 1458 1504–101
Surface Hardness	1760
Wear Resistance	1457 1760 592C

Carbon Steels (contained in B.S. 3100)

Material		*Carbon Content (% maximum)*	*U.T.S. (p.s.i., minimum unless otherwise stated)*	*Yield (p.s.i. minimum)*	*Elongation (% minimum)*
B.S. 592 Carbon steel castings for general engineering purposes	Grade A	0·25	62,720	31,360	22
	,, B	0·35	71,680	35,840	20
	,, C	0·45	78,400	39,200	15
B.S. 1617 Mild steel castings of high magnetic permeability	Grade A	0·15	62,720 (max.)	—	22
	,, B	0·25	58,240 71,680 (max.)	29,120	20
B.S. 1760 Carbon steel castings for surface hardening	Grade A	0·50	89,600	44,800	12
	,, B	0·65	109,800	49,280	10

EMD 8230 for further information

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Low and Medium Alloy Steels (contained in B.S. 3100)

Material	*Grade*	*Carbon Content (% max.)*	*Chief Alloy Constituent (% max.)*	*U.T.S. (p.s.i. min.)*	*Yield (p.s.i. min.)*	*Elongation (% min.)*
B.S. 1398 Carbon-molybdenum steel castings	—	0·25	Mo 0·70	67,200	35,840	20
B.S. 1456 1½% manganese steel castings	A B	0·25 0·33	Mn 1·7 —	78,400 109,800	60% of U.T.S. 60% of U.T.S.	18 15
B.S. 1457* Austenitic manganese steel castings	—	1·35	Mn. 11·0 (min.)	—	—	—
B.S. 1458† B.S. 1459† Alloy steel castings for structural and general engineering purposes.	— —	— —	— —	109,800 123,200	71,680 85,120	15 12
B.S. 1956 1% chromium steel castings, abrasion resistant	A B C	0·55 0·55 0·65	Cr 1·2 Cr 1·2 Cr 1·50	109,800 — —	— — —	10 — —
Chromium-molybedenum steel castings B.S. 1461 3% B.S. 1462 5% B.S. 1463 9%	— — —	0·25 0·20 0·20	Cr 3·5, Mo 0·60 Cr 6·0, Mo 0·65 Cr 10·0, Mo 1·2	89,600 89,600 89,600	53,760 60,480 60,480	18 18 18

* *Mechanical properties of B.S. 1457 subject to agreement between foundry and purchaser.*

† *Composition selected to give indicated properties.*

High Alloy Heat-resisting Steels (contained in B.S. 3100).

Material	*Grade*	*Carbon (% maximum)*	*Chief Alloy Constituent (%)*
B.S. 1648	A	0·25	Cr 12–16
	B	1·00	Cr 25–30
	C	1·00	Cr 25–30
	D	0·4	Cr 17–22, Ni 6 (min.)
	E	0·5	Cr 22–27, Ni 10–14
	F	0·5	Cr 22–27, Ni 17–22
	G	0·5	Cr 15–20, Ni 23–28
	H	0·5	Cr 15–25, Ni 36–46
	K	0·75	Cr 10–20, Ni 55–65

High Alloy Corrosion-resisting Steels (contained in B.S. 3100)

Material	*Grade*	*Carbon Content (% max.)*	*Chief Alloy Constituent (% max. unless otherwise stated)*	*U.T.S. (p.s.i. min.)*	*Yield (p.s.i. min.)*	*Elongation (%)*
B.S. 1630 13% chromium steel castings	A B C	0·15 0·2 0·3	Cr 13·5 Cr 13·5 Cr 13·5	78,400 89,600 109,800	53,760 64,960 67,200	20 18 15
B.S. 1631 Austenitic chromium-nickel steel castings	A B (Nb) B (Ti)	0·12 0·12 0·12	Cr 17·0 (min.), Ni 7·0 (min.) Cr 20·0, Ni 8·5 (min.) Cr 20·0, Ni 7·5 (min.)	67,200 67,200 67,200	30,240 30,240 30,240	20 20 20
B.S. 1632 Austenitic chromium-nickel-molybdenum steel castings	A B C (Nb) C (Ti) D	0·08 0·08 0·12 0·12 0·08	Ni 14·0, Cr 20·0, Mo 4·0 Ni 10·0 (min.), Cr 18·5, Mo 3·0 Ni 10·0 (min.), Cr 18·5, Mo 2·75 Ni 10·0 (min.), Cr 18·5, Mo 2·75 Ni 8·0 (min.), Cr 18·5, Mo 3·0	67,200 67,200 67,200 67,200 67,200	30,240 30,240 30,240 30,240 30,240	15 15 15 15 15

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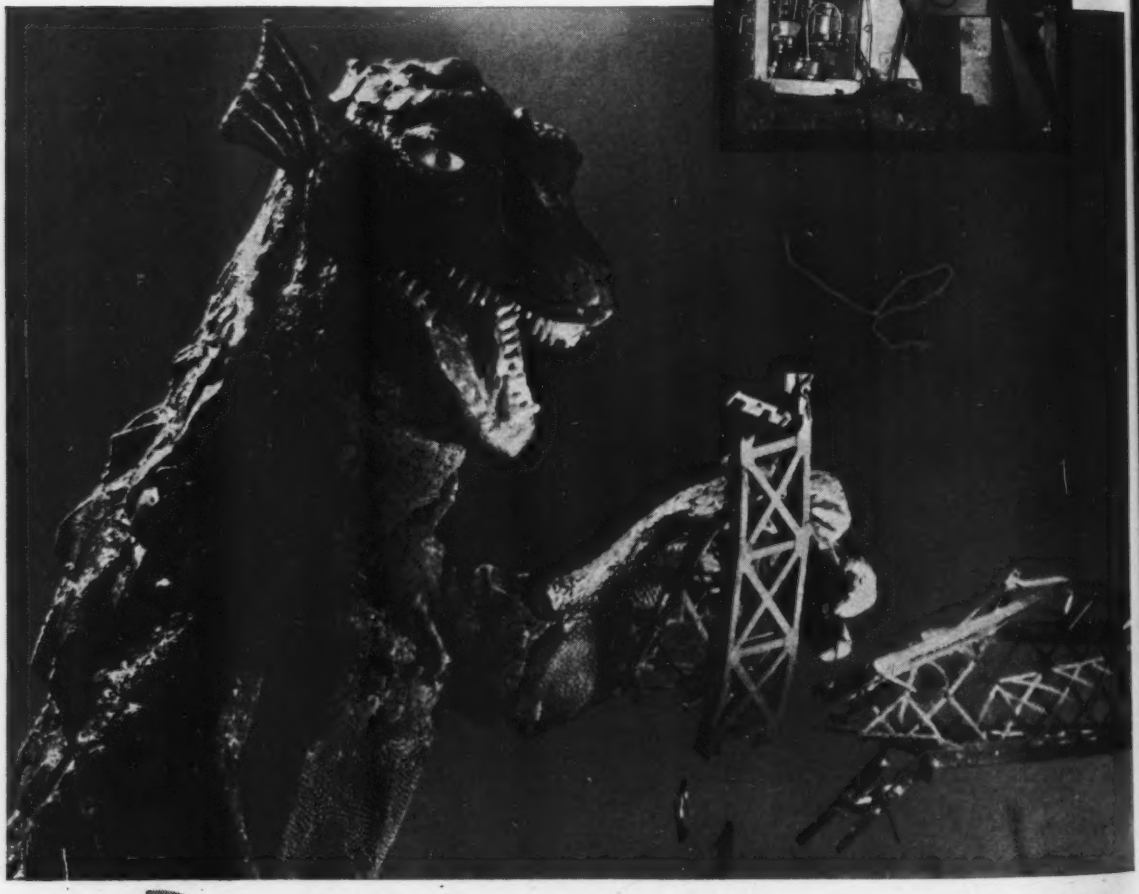

FLUID POWER DIVISION

Baldwin Industrial Controls

Baldwin Instrument Co. Ltd., Dartford, Kent.
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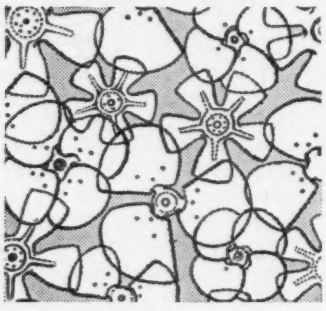
Steels for the Chemical, Petroleum and Allied Industries

British Specification 1504	*Grade*	*Carbon Content (% max.)*	*Chief Alloy Constituent (% max.)*	*U.T.S. (p.s.i. min.)*	*Yield (p.s.i.)*	*Elongation (%)*
B.S. 1504–101 Carbon steel castings for structural purposes	A B C	— — —	— — —	58,240 62,720 78,400	29,120 31,360 39,200	20 20 15
B.S. 1504–161 Carbon steel castings for pressure applications	A B	0·25 0·3	— —	62,720 69,440	31,360 35,840	22 22
B.S. 1504–240 Carbon-molybdenum steel castings	— —	0·25	Mo 0·7	67,200	35,840	20
B.S. 1504–503 3½% nickel steel castings	—	0·15	Ni 4·0	64,960	39,200	25
B.S. 1504–621 1¼% chromium-molybdenum steel castings	—	0·2	Cr 1·5 Mo 0·65	69,440	40,320	20
B.S. 1504–622 2¼% chromium 1% molybdenum steel castings	—	0·18	Cr 2·75 Mo 1·2	69,440	40,320	20
B.S. 1504–623 3% chromium-molybdenum steel castings	—	0·25	Cr 3·5 Mo 0·6	89,600	53,760	18
B.S. 1504–625 5% chromium-molybdenum steel castings	—	0·2	Cr 6·0 Mo 0·65	89,600	60,480	18
B.S. 1504–629 9% chromium-molybdenum steel castings	—	0·2	Cr 10·0 Mo 1·2	89,600	60,480	18
B.S. 1504–713 13% chromium steel castings	—	0·2	Cr 13·5	89,600	64,960	18
B.S. 1504–801 Austenitic chromium-nickel steel castings	—	0·12	(Ni+Cr) 25·0 (min.)	67,200	30,240	20
B.S. 1504–821 Stabilized austenitic chromium-nickel steel castings	Ti Nb	0·12 0·12	(Ni+Cr) 25·0 (min.) Ni 8·5 (min) Cr 17–20	67,200 67,200	30,240 30,240	20 20
B.S. 1504–845 Austenitic chromium-nickel – 2½% molybdenum steel castings	B Nb	0·08 0·12	Ni 10·0 (min.) Cr 18·5 Mo 3·0 Ni 10·0 (min.) Cr 18·5 Mo 2·75	67,200 67,200	30,240 30,240	15 15
B.S. 1504–846 Chromium-nickel – 3½% molybdenum steel castings	—	0·08	Ni 14·0 Cr 20·0 Mo 4·0	67,200	30,240	15

The range of steels listed provides for most combinations of mechanical stressing present in the general run of engineering plant, equipment and machines; applications involving extreme conditions of mechanical and thermal stressing are not covered, nor those involving exceptionally corrosive service conditions. This data sheet has been compiled by courtesy of Brown-Lennox & Co. Ltd., from information contained in their publication *Steel Castings*.

PROPELLER FANS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY



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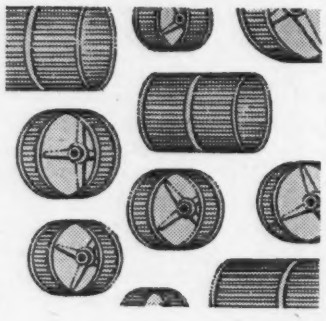

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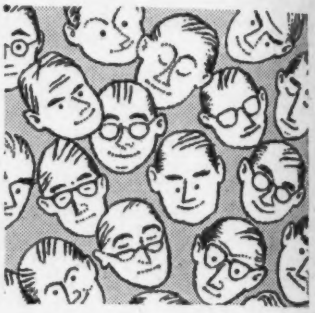

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WEIGHTS OF SHEET MATERIALS

Engineering Materials and Design
DATA SHEET No. 73

The chart on page 853 has been prepared to give the weight of sheet material in lb. per sq. ft. for a given thickness in inches or s.w.g. size. To read it, trace the thickness to the appropriate diagonal and project across to the left-hand scale to read weight in lb./sq. ft.

Since the inclusion of a comprehensive range of materials would crowd the diagonals and make interpretation difficult, a restricted number only of sheet materials are drawn on the chart. Specific weight scales are given which enable the appropriate diagonal to be drawn for any other material for which the specific weight in lb. per cu. in. is known. To construct the diagonal for any other material, enter the specific weight on the appropriate bottom-left and top-right scales and join with a straight line.

Typical Weights of Plywoods (Metric sizes)

Nominal Thickness (mm.)	*Approximate Equivalent (in.)*	*Birch Ply (lb./sq. ft.)*	*Mahogany* Ply (lb./sq. ft.)*	*Average Variation*
1·0	—	0·170	0·17	
1·5	1/16	0·254	0·25	
2·0	—	0·330	0·32	±10%
2·5	—	0·431	0·39	
3·0	1/8	0·516	0·45	
4·0	5/32	0·696	0·60	
5·0	—	0·828	0·70	±5%
9·0	3/8	—	1·20	

* *Makore or Sapele*

Typical Weights of Plywood (inch sizes)

Nominal Thickness (in.)	*Mahogany * (lb./sq. ft.)*	*Birch (lb./sq. ft.)*	*Beech (lb./sq. ft.)*
1/32	—	0·148	0·155
3/64	—	0·210	0·229
1/16	0·215	0·288 ±10%	0·303 ±10%
5/64	—	0·331	0·372
3/32	—	0·404	0·441
1/8	0·44	0·518	0·565
5/32	0·55	0·638	0·675
3/16	0·68	0·745	0·775
1/4	0·81	0·980 ±5%	1·012 ±5%
5/16	—	1·270	1·336
3/8	1·20	1·555	1·622
7/16	1·58	2·000	2·090
1/2	1·96	2·490 ±2½%	2·593 ±3%
9/16	2·25	2·980	3·118

* *Makore or Sapele*

Specific Weights of Metals

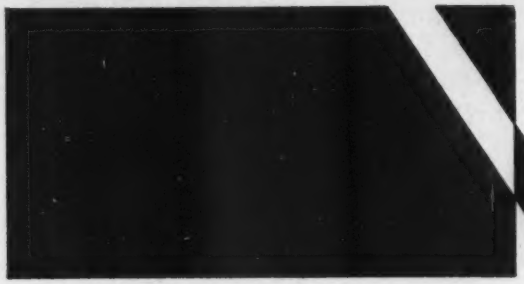
Metal	*lb./cu. in.*
Alclad	0·1015
Aluminium	0·0975
Aluminium-bronze	0·293
Brass	0·307
Bronze	0·308
Copper	0·318
Duralumin	0·1015
Gunmetal	0·306–0·314
Hiduminium	0·1015
Iron (cast)	0·260
Iron (wrought)	0·283
Lead	0·410
Magnesium	0·063
Magnesium alloy	0·065–0·095
Monel	0·320
Nickel	0·318
Steel	0·283
Tu	0·304
Zinc	0·253

Specific Weights of Woods

Wood	*lb./cu. in.*
Ash	0·026
Balsa (8 lb.)	0·005
Beech	0·027
Birch	0·023
Cedar	0·020–0·026
Douglas fir	0·020
Elm (English)	0·020
Elm (Canadian)	0·026
Larch	0·026
Lime	0·020
Mahogany (true)	0·023–0·031
Maple	0·025
Pine	0·017–0·021
Pitch pine	0·030
Poplar	0·014
Spruce	0·016
Teak	0·030
Walnut	0·025
Western Hemlock	0·018
Yellow Pine	0·018

Miscellaneous Specific Weights

Material	*lb./cu. in.*
Acrylate	0·057
Acetate Sheet	0·047
Micarta	0·048
Paxolin	0·050
Perspex	0·043
Polystyrene	0·040
P.v.a.	0·044
P.v.c.	0·047
Tufnol	0·050
Armour Plate	0·294
Asbestos	0·137–0·209
Bakelised fabric	0·046
Cork	0·01
Ebonite	0·05
Fibre, red	0·049
Fibre, grey	0·043
Glass (plate)	0·10
Leather	0·03 (average)



The SHAPE of things

A quiet revolution is taking place in the use of materials in Industry.

As the value of the first class functional design gains ever increasing appreciation, so the scope of the Industrial Designer becomes wider and his search for new materials more intense.

This is why more and more designers have in recent years turned to Hawley Moulded Fibre with its distinct advantages over most conventional materials in resilience, versatility and strength/weight ratio.

Now an even better material is available to Industry on a production basis. The new Hawley Aqueous Mix Polyester Glass Fibre mouldings, protected by patents in Great Britain and many other countries, offers unlimited scope. Thinner, lighter, yet stronger than ever before and available in a wide variety of attractive finishes, this new and revolutionary material must surely be of interest to all concerned with Product design.

May we send you further information?

These Antler suitcases, handsomely covered with PVC and fitted with a stainless steel section on the edges are a good example of functional design. A pair of plain shells with a glass fibre content weighs approximately 3¼ lbs and they have a tensile strength of 7500 lbs/sq. in. and a flexural strength of 9500 lbs/sq. in.

Hawley

HAWLEY PRODUCTS LIMITED
CHENEY MANOR · SWINDON · WILTS
TELEPHONE: SWINDON 6251

To HAWLEY PRODUCTS LIMITED
Cheney Manor, Swindon, Wilts

Please ask your representative to telephone for an appointment.

Please send me a copy of your brochure.

Name.....

Title.....

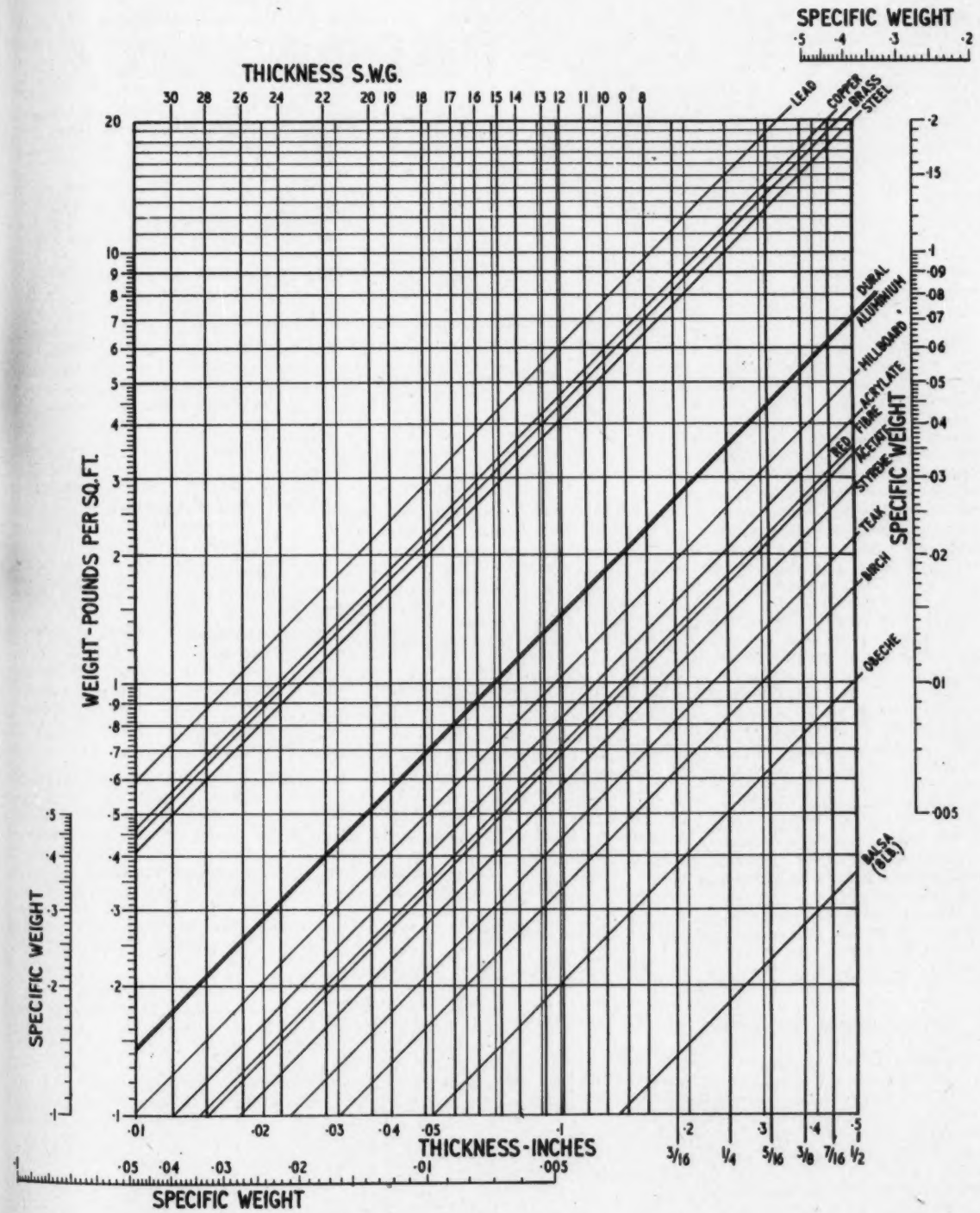
Company.....

Address.....

.....Phone.....

HP18

WEIGHTS OF SHEET MATERIALS (contd. *from page 851*)



New Books

Impact Testing of Materials. *By W. Späth. Revised and adapted by M. E. Rosner.* (*Thames and Hudson*—25*s.*)

Dr. Späth has developed a small machine for making Izod type impact tests. The pendulum takes the form of an out-of-balance wheel which allows the use of a low striking velocity combined with adequate available energy and travel. The energy absorbed in fracturing the specimen is measured as usual but the maximum force employed is also recorded. This is made possible by spring-mounting the vice holding the specimen. This is a radical departure from general practice and a comparison between the test figures obtained from this machine and those obtained by testing similar specimens on standard machines might be expected. No such comparison is mentioned.

The book is in three parts. The first part is a survey of current practice in the impact testing of a wide range of materials including ferrous and non-ferrous metals, plastics, timber, concrete, adhesive-bonded materials and textile fibres. Many test results are quoted from the literature to illustrate the complexity of the behaviour of most materials and the dependence of energy required to fracture a specimen on such variables as temperature, geometry and the structural conditions of the material due to previous cold work, heat treatment or surface finish. The references (181) are almost exclusively to work published in German.

Part Two consists of a very brief description of the machine with a report on "preliminary tests" on a selection of materials from the range discussed in Part One. The main aim of the tests is to classify materials as "tough" or "brittle".

In the third part the author develops further his ideas on the measurement of this elusive quality of "toughness". Of recent years much work and thought has been devoted to what is usually described as the problem of brittle fracture, particularly with reference to steels. Dr. Späth's ideas seem to be rather outside the present stream.

The translator has not been consistently successful in naturalising the phraseology of the original work and occasionally the meaning is obscure.

A. Ormerod

OTHER BOOKS RECEIVED

Classified Handbook of Members 1961. (*British Engineers Association*—21*s.*)

Classified handbook of members, their products, trade names and marks. Indexed in Portuguese, French, German and Spanish.

BS A212:1961. Cadmium-plated Steel Bolts of High Metallurgical Quality (Unified hexagons, Unified threads and close tolerance shanks) for Aircraft. (*British Standards Institution*—5*s.*)

The Protection of Circuits by Miniature Circuit-breakers. (*E.R.A. Report F/T197*—10*s.* 6*d.*)

This report is concerned mainly with thermal effects in the protected cable during the operation of miniature circuit-breakers.

BS 15:1961. Mild Steel for General Structural Purposes (*British Standards Institution*—5*s.*)

This revised edition specifies the process of manufacture and lays down limits for carbon, copper, sulphur, and phosphorus. It also specifies the tests to be carried out on plates, sections and round and square bars together with the special tests required on rivet bars and rivets.

BS 899:1961. Rolled Copper Sheet, Strip and Foil (*British Standards Institution*—6*s.*)

The new revision has extended the standard's scope to include material for electrical purposes in the form of rolled sheet and strip. This material was previously covered by BS 1432 which is now being revised.

BS 1452:1961. Grey Iron Castings. (*British Standards Institution*—5*s.*)

The revision specifies the requirements for seven grades of grey iron castings varying in strength. The methods of test, dimensions of test bars and test requirements are specified, and details are provided of the process of manufacture.

BS 1828:1961. Reference Tables for Thermocouples. (*British Standards Institution*—6*s.*)

Tables for copper/constantan thermocouples to enable conversion of thermocouple voltages into equivalent temperatures.

BS 3360:1961. (*British Standards Institution*—7*s.* 6*d.*).

Dealing with the requirements for copper conductors in insulated cables and cords. Tests are prescribed for resistance, quality of tinning, and mechanical properties.

BS 3361:1961. (*British Standards Institution*—7*s.* 6*d.*).

Similar to BS 3360:1961, except that the requirements are given in metric units.

BS 3396. Woven Glass Fibre Fabrics for Plastics Reinforcement, Part 1 and Part 2: 1961, Loom-state fabrics and Desized Fabrics. (*British Standards Institution*—6*s.*)

Part 1 gives manufacturing requirements; Part 2 covers the same fabrics after a desizing treatment. Methods of test are given. **Part 3: 1961 Finished Fabrics for Use with Polyester Resin Systems** (4*s.* 6*d.*). Gives details of requirements for glass fibre fabrics specified in Parts 1 and 2.

BS 3401:1961. Beryllium Copper Crinkle Washers. (*British Standards Institution*—3*s.*)

The present specification covers washers in sizes suitable for use with screwed fasteners from 10 B.A. to $\frac{3}{4}$ in. nominal diameter.

BS 3409:1961. Tapping of Holes to Receive Wire Thread Inserts (UNC and UNF threads). (*British Standards Institution*—7*s.* 6*d.*)

This specification gives limits of size for tapped holes to accommodate wire thread inserts from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. UNC and from $\frac{1}{4}$ in. to 1 in. UNF.

BS 3410:1961. Metal Washers for General Engineering Purposes. (*British Standards Institution*—6*s.*)

Specifies requirements for material, finish and dimensions for small and large bright washers for use with B.A., UNC, UNF, B.S.W. and B.S.F. fasteners.

This standard supersedes washers in BS 57, 325, 916, 1083, 1768, 1769, 1981, 2466, and 2708.

FOREIGN TRANSLATIONS

Instrument Construction. (*Subscription £6 per annum*)

A monthly translation from the U.S.S.R. journal *Priborostoenie*, produced for D.S.I.R. by B.S.I.R.A. and published by Taylor & Francis Ltd.

Soviet Plastics. (*Subscription £14 per annum*)

A monthly translation of *Plastickeskie Massy;* produced for D.S.I.R. by Rubber & Plastics Research Assoc. of Gt. Britain and published by Rubber & Technical Press Ltd.

Bulletin of the Research Council of Israel 3rd Annual Conference on Aviation and Astronautics. (*Israel Institute of Technology*)

Russian Castings Production (*Subscription £10 10s. 0d. per annum*)

A monthly translation of *Liteinoe Proizvodstvo,* published by the British Cast Iron Research Association.

T.D.A. REPORTS

The following have recently been published by the Timber Development Association:

Plywood (5*s.*)

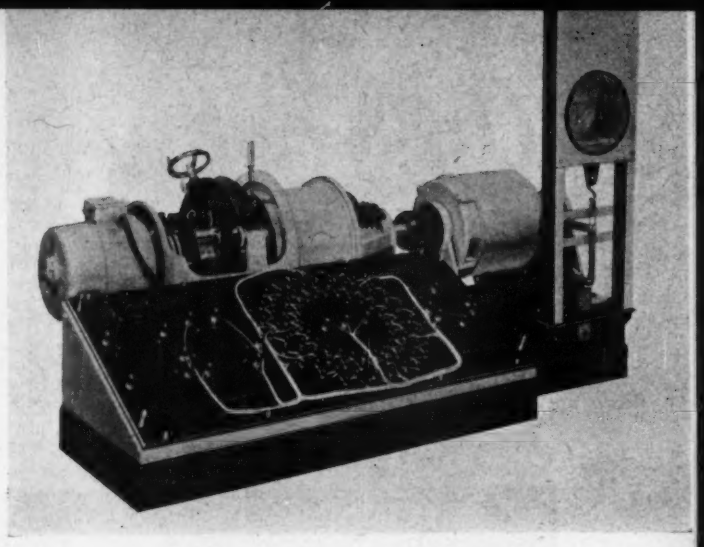
Sea Defence Groynes—(B/IB/1. (3*s.* 6*d.*)

Resistance of Certain Timbers in Sea Defence Groynes to Shingle Abrasion—B/TR/4 (3*s.* 6*d.*)

Comparative Test on the Nailing Properties of European Redwood and Western Red Cedar—E/TM/40. (3*s.* 6*d.*)

A Non-destructive Method for Measuring the Elastic Anisotropy of Wood using an Ultrasonic Pulse Technique—*E/RR*/9 (3*s.* 6*d.*)

The Mawdsley prototype generalised electrical machine, introduced at the 1961 A.S.E.E. Exhibition.



A NEW ELECTRICAL MACHINE FOR TEACHING PURPOSES

FOR many years the subject of electrical machinery has has been taught by traditional methods covering steady-state working. Each type of machine was considered in turn, starting with the d.c. machine and proceeding through the transformer, the induction machine and the synchronous machine. Special machines and transient operations were dealt with if time permitted. A full understanding of the transient operation of machines has now become very important, particularly in regard to machines as elements in control systems, and a new approach to the subject is necessary.

There is a danger that students who are taught the general theory will become merely mathematical "handle turners", without the real understanding which an engineer ought to have. A lecture course using such an approach must take account of this danger, and should have a concurrent laboratory course which includes experiments with a generalised machine.

It was for this purpose that the A.E.I. Generalised Machine Set* was designed. This set incorporates a generalised electrical machine coupled on a common baseplate to a d.c. shunt machine for motoring and loading. The coupling forms a torque-measuring device for indicating both transient and steady-state torques.

The generalised machine can be connected for operation as any one of the conventional types of electrical machine, such as d.c. shunt series; compound or cross field excited motor and generator; induction machine; synchronous machine; a.c. commutator motor; or repulsion motor. It can also operate in one unconventional mode, being equipped with a small auxiliary motor for continuously rotating one of the sets of commutator brush gear. It is limited in so far as the stator winding is distributed, and so no account can be taken of saliency effects.

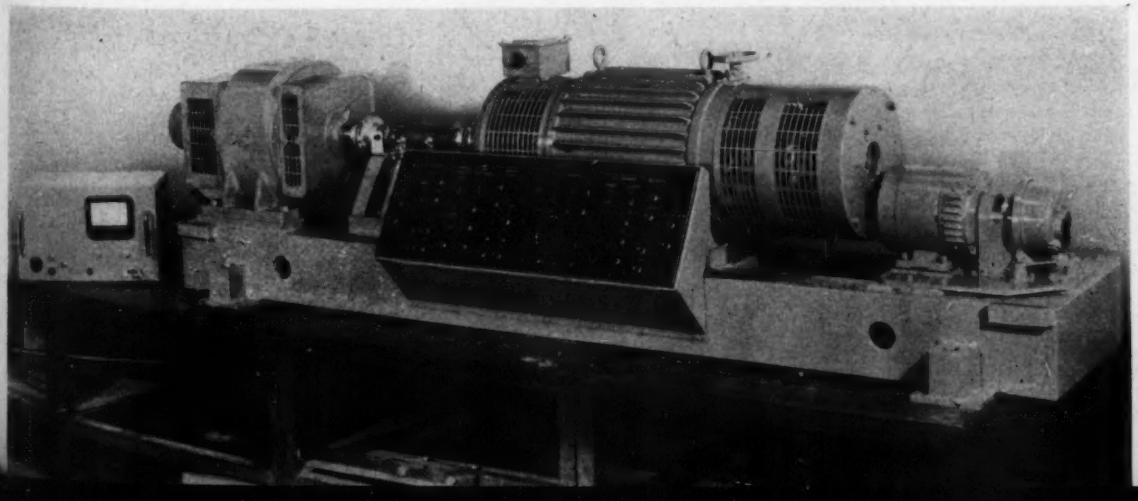
In association with a cathode-ray oscilloscope, camera, pen-recorder and function generator, it can be used in studies of electrical and mechanical transient problems associated with all these machine types, e.g. synchronous torque in a.c. machines, and the speed transients of d.c. machines. Another very important advantage is that the flexibility of the generalised machine allows almost unlimited scope for initiative and enthusiasm by the student, who can extend his formal work as he wishes.

Several engineering schools in Britain already teach generalised machine theory in the final year of their undergraduate courses, as a special and additional course to the more or less conventional one of the previous year. It may well be that with the growth of fundamental scientific knowledge having a bearing on electrical engineering, the amount of new material taught will continue to increase. The universities will be obliged to place even greater emphasis on fundamental principles, and increasingly eliminate from their courses those techniques which can only be properly studied in an industrial environment. This tendency is likely to lead to a wider use of the more fundamental approach to machines.

It is evident that one or more generalised electrical machine sets, having the mechanical and electrical features described in this article, will soon be an essential part of the modern electrical power laboratory.

*See *A.E.I. Engineering*, September 1961.

Generalised electrical machine set developed by A.E.I. in collaboration with Queen Mary College, University of London.

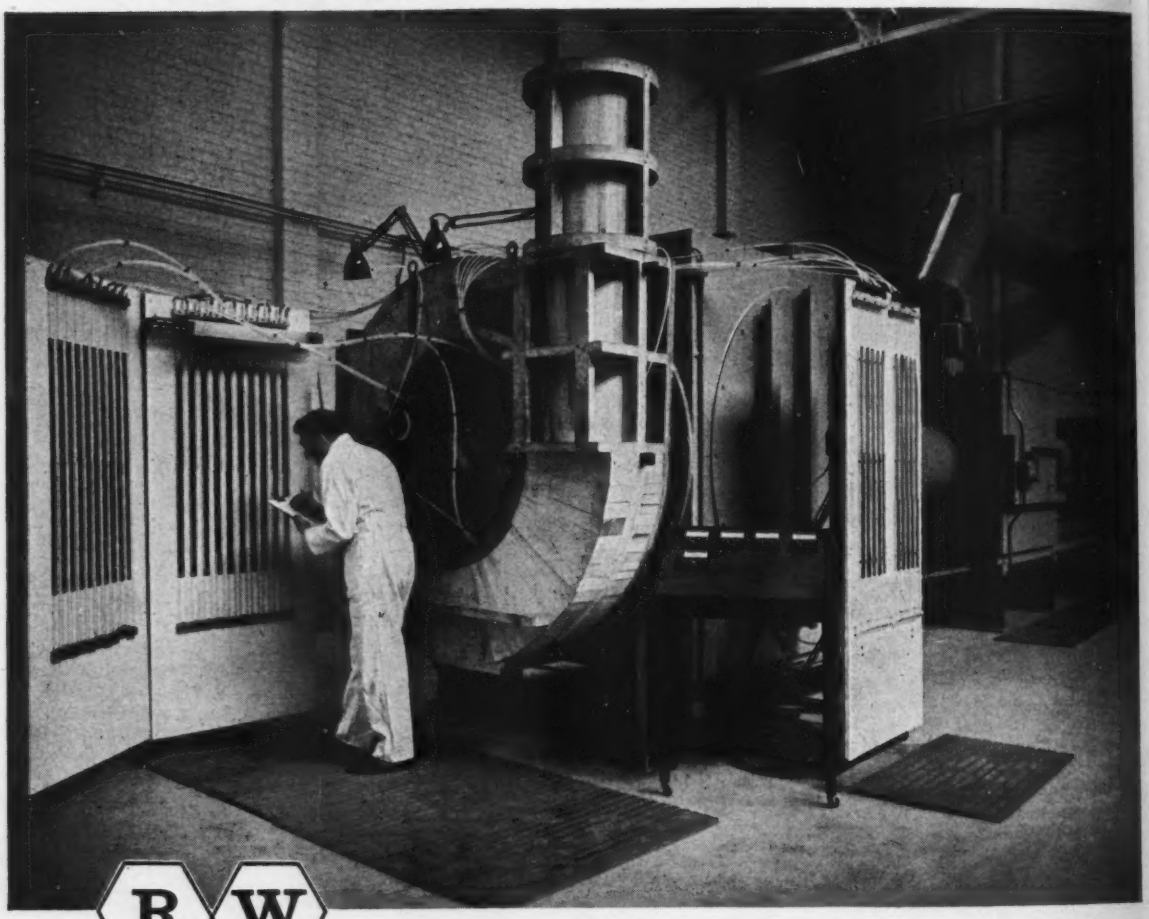


EMD 8236 for further information

You'll get no stock answers here!

On the Development side at Richardsons Westgarth we work from principle, not precept, and use a conventional solution to a problem only when we are sure it is the economic one.

It is this outlook that has enabled us to provide new answers to many problems in mechanical engineering, from turbo-machinery to sea-water distillation plant.



R W G

In the Aerodynamics Laboratory of the Richardsons Westgarth Group, an engineer tests an air flow model of the outlet diffuser and volute assembly for a high-speed centrifugal compressor. These volutes and diffusers will be used on a number of gas turbo-compressors at present being manufactured for a well-known Oil Company.

RICHARDSONS, WESTGARTH & CO. LTD.

The Controlling Company of the Richardsons Westgarth Group, Wallsend, Northumberland and at 58 Victoria Street, London, S.W.1. 59 Mosley Street, Manchester. 75 Buchanan Street, Glasgow.

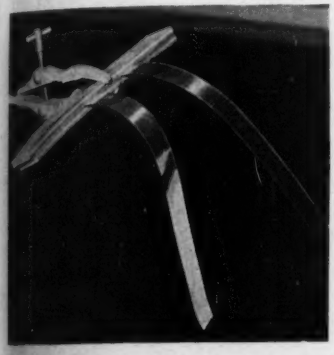
RWB8A

WHAT'S NEW IN MATERIALS

Tougher Aluminium Foil

A new hard aluminium foil—known as N.S.4—is being rolled for the first time in Britain in thicknesses down to 0·025 mm. N.S.4 is said to differ from commercial purity aluminium in containing 1·8-2·7% magnesium and up to 0·5% each of manganese and chromium.

The production of foil from this alloy is described as meeting a call from industry for a foil of greater stiffness and strength than can be rolled from commercially



pure aluminium, or from the 1·25% manganese alloy N.S.3. This demand comes from industries as widely apart as the aircraft industry, where it is used as the honeycomb centre of flooring, to the display industry for the manufacture of collapsible foil Christmas trees. Both use N.S.4 foil in the hard temper.

In this temper and in 0·06 mm. thickness, N.S.4 has a tensile strength of 16-18 t.s.i. as against 9 t.s.i. for commercial purity aluminium and about 11-12 t.s.i. for N.S.3. *Venesta Foils Ltd.*, Thorn House, Upper St. Martins Lane, London, W.C.2.

EMD 8315 for further information

Low-stress Rhodium-plating

A new electrolyte developed by The International Nicked Co. (Mond) Ltd. is said to enable the deposition of heavy deposits of low stress (possessing a hardness of 700-800 D.P.N.). This electrolyte is similar in general chemical nature to the conventional type of sulphate solution, and the containers, anodes and the general operating procedure are as for a conventional solution. For optimum results, however, a number of precautions must be carefully observed.

Best results in terms of deposit brightness are obtained on well-polished surfaces; thorough cleaning is essential.

The recommended current density is 10 amps./ft.^{2} With an operating temperature of 50 deg. C., the rate of deposition will be in the order of 0·0001 in. (2·54 microns) in 20 min. Lower current densities are permissible, but the upper value should never exceed 20 amps./ft.^{2} The efficiency of the electrolyte is the same as that of a conventional sulphate solution. *Engelhard Industries Ltd.*, Baker Platinum Division, 52 High Holborn, London, W.C.1.

EMD 8316 for further information

Beryllia-free Copper Strip

All Mallory 73 beryllium copper strip up to 0·025 in. thick is now being supplied with beryllia-free surfaces. This is designed to reduce tool wear without affecting the mechanical properties of the alloy.

Undue tool wear is attributable to the presence of beryllia, a hard and abrasive oxide of beryllium that is formed during the solution heat treatment of the alloy. The oxide is colourless and is not removed by normal cleaning or pickling methods, so that it is often present on material that appears to have a good surface finish.

A new process developed by the manufacturers completely removes beryllia, and the improved material is supplied at no extra cost. *Johnson, Matthey & Co. Ltd.*, 73-83 Hatton Garden, London, E.C.1.

EMD 8317 for further information

Non-metallic Shotblast Abrasive

A non-metallic shotblast abrasive, called No-Met, is just announced. The new product is reported to be less than one-fifth the price of the conventional metallic abrasive.

Shotblasting is now generally recognised as the best way of preparing large areas of steel work for painting, but site conditions may prevent recovery of the abrasive material. No-Met was developed to fulfil the demand for a cheap, expendable abrasive for this type of work.

Recent trials on bridges, ships' hulls and oil tanks have left steel surfaces with an excellent key for priming paints. No-Met is free of silica and thus complies with the shotblasting regulations. *Bradley's (Darlaston) Ltd.*, Darlaston Iron Works, Darlaston, Staffs.

EMD 8318 for further information

Aerosol Cutting Lubricant

A new move in the development of specialised lubricants in industry is shown in the announcement of the latest addition to the range of cutting lubricants available.

This is a spray in an aerosol form of R.T.D. compound which is already well known as an efficient cutting lubricant, originally introduced for reaming, tapping and drilling and now used extensively for difficult operations on all materials.

The development of this spray is said to enable R.T.D. compound to be applied "at the touch of a button", a unique method for this type of lubricant.

Originally introduced because of its ease and handiness, the spray has been found to have many technical advantages, especially for application in die-boxes, penetration down flutes of tools, covering of forming tools and dies and for following moving work-pieces. It eliminates the messiness of a brush and pot and is of advantage in all machines not fitted with a suds pump and reservoir. *Rocol Ltd.*, Rocol House, Swillington, Leeds.

EMD 8319 for further information

Improved Polyester Tape

Sellotape yellow polyester thermosetting tape is a thin filmic insulating medium which remains stable at high temperatures.

An improved polyester thermosetting tape is now available to the electrical industry. Laboratory research has evolved a special processing treatment which is claimed to prevent curling of the tape when it is dispensed. This was previously due mainly to a build-up of static electricity in the film; the new treatment prevents this build-up. A further advantage is that it is now easier to draw off tape from the roll, requiring less effort.

These improvements make possible speedier tape application with appreciable saving in labour on repetitive operations. They have been incorporated without impairing the tape's characteristic high tack and good electrical qualities in any way. *Gordon & Gotch (Sellotape) Ltd.*, 8-10 Paul Street, London, E.C.2.

EMD 8320 for further information

Micro-mesh

Recently announced is the introduction of a new and widening range of perforated metal—Perflec electro-formed mesh with hole sizes from 0·027 down to 0·003 in. "Specials" may be produced with holes as small as 0·001 in.

Perflec, which is the only material of its type made in the U.K., consists of a pure copper core heavily clad with pure nickel. Normal thicknesses (depending on the mesh count) range between 0·010 and 0·003 in. It is flat, smooth, tough and can be easily cut, punched, bent or formed. Perflec cannot fray and edge binding is normally unnecessary. The rigid integral construction gives freedom from aperture distortion under stress and permits formed cylinders to be used unsupported. By virtue of its nickel-clad copper construction Perflec is ideal for hard or soft soldering and spot or seam welding.

Remarkable regularity of pitch and aperture size are said to be important Perflec characteristics and the unique slight taper of the square apertures has afforded exceptional results where filters are "back washed" for cleaning.

Standard Perflec is produced in rolls 3 ft. wide and up to 100 ft. long. It is available in five counts producing fifteen aperture sizes and thicknesses. Additions to the range are continually being made. *N. Greening and Sons Ltd.*, Perflec Dept., Britannia Works, P.O. Box 22, Warrington, Lancs.

EMD 8321 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

418mm Dia!

A large moulding in Beetle DMC for the aircraft industry, moulded by AB. Malmö, Flygindustri, Sweden.

WHEN YOU NEED LARGE MOULDINGS with great strength you will find Beetle DMC an unbeatable material. Equally outstanding for its electrical insulating and anti-tracking properties as for its strength and heat resistance, DMC cures rapidly and moulds easily at low pressures in conventional compression and transfer presses. Dimensional stability and compatibility with metals are excellent. Three types are available: Type A – glass-filled for general purpose and electrical components; Type B – glass-filled self-extinguishing; Type C, an economical sisal-filled material. Write for full details.

BEETLE polyester Dough Moulding Compound

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B·I·P

WHAT'S NEW IN MATERIALS

Polythene Resin

To meet the growing demand for a tough, high impact polythene film for use in industrial applications in the packaging industry, a new grade of material—Bakelite polythene resin PY.300—has been produced.

Tests carried out are said to have shown that this new resin will produce a standard clarity film of exceptionally high impact strength (in thicknesses down to 100 gauge) without sacrificing extrudability or other desirable fabricating properties.

In addition to their uses in pre-packing and industrial wrapping, films based on the new material are expected to be of particular advantage in the handling of hygroscopic materials, as backings for industrial tapes and for applications in the building and agricultural industries. *Bakelite Ltd.*, 12-18 Grosvenor Gardens, London, S.W.1.

EMD 8322 for further information

P.t.f.e. Pipe Thread Sealing Tape

P.t.f.e. pipe thread sealing tape is supplied as a continuous ribbon ½ in. wide on metal dispensers in lengths of 20, 30 or 40 ft. This unsintered tape is used for the rapid sealing of threaded pipe joints. Breaking of the connection is said to be easily accomplished, even after a long period of time.

The plasticity of the material ensures that it conforms exactly to the contours of the thread, resulting in a perfect seal

against high pressures. It is also said to be unaffected by temperatures ranging from −100 to +300 deg. C. It is chemically inert, and will not cause contamination of the liquid being handled.

The tape is claimed to be impervious to water, steam and most corrosive liquids and gases, and to be unaffected by ageing or weathering. *Turner Brothers Asbestos Co. Ltd.*, P.O. Box 40, Rochdale.

EMD 8323 for further information

Antimony-clad Strip

Manufacturers of semiconductor devices are now being offered sample quantities of Nilo-K strip clad on each side with 0·5% gold-antimony. It is hoped that production quantities will be available early in 1962.

The strip is available in widths between ⅛ and 2 in., in thicknesses down to 0·005 in. The thickness of cladding that can be supplied on each face is either 11·5 or 18·75% of the total thickness. *Johnson, Matthey & Co. Ltd.*, 73-83 Hatton Garden, London, E.C.1.

EMD 8324 for further information

Dielectric Polystyrene

Availability of a new dielectric material for the electronic and electro-mechanical industries has been announced.

Known as Polypenco Q-200.5 this interesting product is a cross-linked polystyrene having excellent rigidity, the ability to resist deformation under load and high impact strength.

Q-200.5 is claimed to have negligible water absorption, is transparent and may be used permanently at temperatures of 100 deg. C. For short periods of time the material is form stable up to temperatures as high as 204 deg. C.

The material has outstanding properties as an ultra high frequency insulator up to 10,000 megacycles. The loss tangent of the material compares favourably with that of polytetrafluoroethylene and polythene and both volume and surface resistivities are better than p.t.f.e. at low frequencies. The dielectric constant is subject to little variation over the widest frequency range.

Readily machined on orthodox metalworking equipment, this cross-linked polystyrene can be supplied from stock in round rod form ⅛ to 3 in. dia., and in plate form ¼ to 1 in. thick.

The material is intended to augment the existing Polypenco range of dielectric materials available to industry; these include p.t.f.e. shapes and Fluorosint (p.t.f.e. base resin) shapes and moulded parts. *Polypenco Ltd.*, 68-70 Tewin Road, Welwyn Garden City, Herts.

EMD 8325 for further information

P.v.c. Window Stickers

Printed non-adhesive p.v.c. window stickers, which provide a good medium for point-of-sale and message presentation on any glass or shiny surface, are the latest addition to the range of printed tapes and labels available.

Based on a non-adhesive plasticised p.v.c. film and obtainable in varying sizes in a wide selection of striking colours and designs incorporating any appropriate slogan, the stickers are said to be non-ageing and impervious to the normal effects of the atmosphere. As they are uncoated they can be removed without leaving any adhesive deposits and furthermore can be reapplied repeatedly.

Their cost, which the company states is comparatively low, depends entirely on a manufacturer's individual requirement. *Paynes Jiffytape Ltd.*, 1-6 Speedy Place, Cromer Street, London, W.C.1.

EMD 8326 for further information

Phosphating Process

Kephos, which has just been introduced in the U.K., is a non-aqueous phosphating process which dispenses with rinsing and tank-heating, forms no sludge in the processing tank and produces a sealed phos-

phate coating. The phosphate coating is claimed to enhance paint adhesion and resistance to rust creep in the same way as conventionally produced zinc or iron phosphate coatings. The improvement in the corrosion resistance of paint systems is outstanding and the possibility of work being contaminated by water-borne impurities is eliminated.

Kephos contains a sealer which is sufficiently corrosion resistant to protect work during transport or temporary exterior storage for up to a week, or indoor storage up to six months. Under normal production conditions, work can be welded through the Kephos film. This enables items to be treated before fabrication, so that shrouded areas such as interior box sections receive some protection.

Kephos is not confined to dipping. It may be applied by brush, roller, spray or flow-coating, the most suitable method depending entirely on the characteristics and number of the articles to be treated.

The process can be used to supplement existing phosphating facilities when an article is too large for the plant or an abnormal volume of work requires processing. For regular use, its higher chemical cost is offset by the compactness and simplicity of plant requirements and the saving in heating and plant maintenance costs, particularly for the manufacturer of a small volume of high quality production. The recommended system is to degrease all work on arrival and apply Kephos before it is put in store; it is thus simultaneously protected and phosphated during storage and subsequent assembly, requiring only the removal of surface dirt to prepare it for painting. *Imperial Chemical Industries Ltd.*, Millbank, London, S.W.1.

EMD 8327 for further information

Whatever started it, one thing is certain; *combustible materials kept it going.* It's sound sense, then, to investigate the proved qualities of Het Acid. Materials fabricated from polyesters based on Het Acid will not support combustion. Unfed, the fire dies at source.

In addition, Het Acid based resins offer fabricators:
☐ High strength with light weight ☐ Non-deterioration of fire-retarding properties in all climates ☐ Resistance to corrosion and chemical attack ☐ Resistance to temperatures up to 150°C.

HET ACID for self-extinguishing polyesters

POLYESTER RESINS based on Het Acid have already been used to advantage for: roof lighting and decorative translucent panellings; boat construction; chemical plant; housing for motors and electrical equipment; insulating laminates for switch-gear; ductings in aircraft; the manufacture of radomes, and many other applications. Resins based on Het Acid open up exciting possibilities to fabricators in every field of industrial research and development.

These polyesters are made by leading resin manufacturers. We will be pleased to send you complete information on request.

ALBRIGHT & WILSON (Mfg) LTD

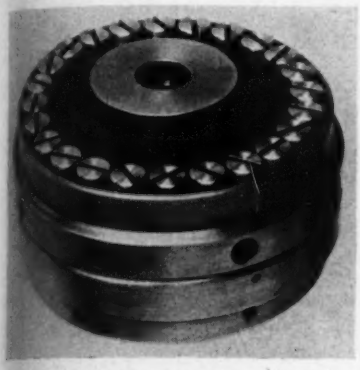
SECTION HR1, Organic Chemicals Department
1 Knightsbridge Green, London, S.W.1. KEN 3422

ea/33

WHAT'S NEW IN COMPONENTS

Torque Limiter

With the new Imostat torque limiter the torque to be transmitted is pre-set at the manufacturer's works, and remains

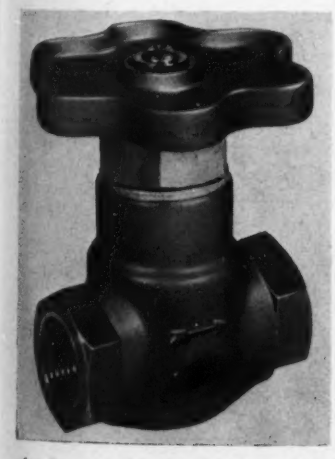


constant indefinitely—it can be readjusted only by authorised personnel. There is practically no decrease of torque transmission capacity when the coupling slips, and heat is effectively absorbed by the iron masses of the coupling even during prolonged periods of slip. *Henry Pels & Co. Ltd.*, 32-38 Osnaburgh Street, N.W.1.

EMD 8328 for further information

Gunmetal Stop Valves

Simplifix Type 60 valves are now available in the following sizes: ¼, ½, ¾ and 1 in. BSP (female). All these valves are manufactured in gunmetal, which gives a good resistance to corrosion. The spindles are made from manganese bronze, and have a fine thread which facilitates opening and closing. The spindle seal is inside the thread, and so the medium in the



valve does not come into contact with the thread. The valve tip is of nylon.

The port connections on this range of valves are suitable for Simplifix stud couplings, which can be fitted as extras. Thus the valves are available for a very large range of pipe sizes.

These valves are designed for use in either pneumatic or hydraulic circuits, or with non-corrosive gases. The following are the maximum working pressures:

	Hydraulic	*Gases*
¼-in. in-line	... 1,000 p.s.i.	200 p.s.i.
½-in. in-line	... 600 p.s.i.	150 p.s.i.
¾-in. off-set	... 400 p.s.i.	100 p.s.i.
1-in. off-set	... 250 p.s.i.	100 p.s.i.

All valves are individually tested to one and a half times the working pressures before they leave the works. They are not suitable for use with steam. *Simplifix Couplings Ltd.*, Hargrave Road, Maidenhead, Berks.

EMD 8329 for further information

Ball Flow Indicator

A 1-in. size Arkon ball flow indicator is now available. The body of this unit is made of gunmetal, and flow is indicated by the movement of a white nylon ball under a toughened glass dome. The starting flow on liquid is ¼ g.p.m. and on

gas 2 c.f.m. If the flow stops the ball drops out of sight. The movement of the ball cannot be missed even in a bad light and at a distance. *Walker Crosweller & Co. Ltd.*, Cheltenham, Gloucs.

EMD 8330 for further information

Semi-tubular Rivets

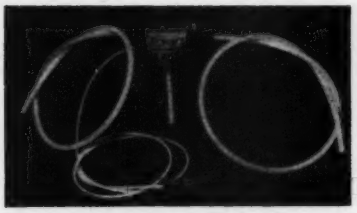
A new range of drilled semi-tubular rivets is now being produced in mild steel, copper, brass and aluminium alloys to British Standard specifications, and particularly to special order as for example where special head shapes and sizes are required. The size range is from ¼ to ¾ in. dia. and up to 6½ in. in length. *Cooper & Turner Ltd.*, Vulcan Works, Vulcan Road, Sheffield 9.

EMD 8331 for further information

Chemical Feeder

For applications involving chlorinating, defoaming, rust and scale inhibition, wash water detergents, and cooling water treatment, the FP Micro H chemical feeder is now being marketed in Britain.

This chemical feeder is designed to feed, meter and regulate very low flow rates of a chemical solution continuously into a liquid stream through its built-in



ejector. By virtue of its plastics construction the instrument can be used with a very wide range of corrosive fluids. The reagent flow rate is manually set and automatically controlled by an integral differential pressure regulator.

The unit is supplied with two 4-ft. lengths of plastics tubing with adaptors for the supply and solution lines, and a 6 ft. length of plastics tubing fitted with a filter for the reagent lines. *Fischer & Porter Ltd.*, Salterbeck Trading Estate, Workington. Cumberland.

EMD 8332 for further information

Elapsed-time Meter

A new elapsed-time meter for recording the time a piece of equipment has been in use is being produced. It can be applied to any equipment which is used intermittently, and on which planned maintenance or a time log is required, e.g. pumps, ventilating and heating systems, and vacuum valves (X-ray transmitting tubes, etc.). The meter is normally connected so that it is automatically switched on and off with the apparatus being metered. It can register up to 9999·9 hr. in steps of 0·1 hr.

The cyclometer register is driven by a self-starting, non-reversing, synchronous motor through a train of gears. Operation is on a.c. supply in the voltage ranges 100-125, 200-250 and 400-440. The frequency can be 50 or 60 c/s. The meter is available in two case types. The first, type H21M, is a 4 in. square, flush-mounting switchboard pattern case. The motor is mounted internally, and two terminals are provided on the base plate to connect the motor to the supply. The meter has a small revolving pointer to indicate that the motor is energised.

The second is a 2½ or 3½ in. (type S25 or S35) square moulded black plastics case designed primarily for panel mounting. The motor is mounted externally, and connection to the supply is made via a pair of flexible leads. It is lubricated with a special grease for operation in extreme temperatures. *English Electric Co. Ltd.*, Strand, London, W.C.2.

EMD 8333 for further information

Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on each card.

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Consistent transmission of power
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10/73

WHAT'S NEW IN COMPONENTS

Accelerometers

The T.C.L. accelerometer type G88 has been designed to meet the requirement for a light-weight high-sensitivity transducer suitable for shock and vibration measurements in G.W., aircraft, packaging and general-purpose use. It utilises T.C.L. piezoelectric ceramic material having a wide temperature range, low temperature coefficient and excellent long-term stability.

The bender unit in this accelerometer has a high value of capacitance, which enables measurements to be made at a few c/s into a cathode follower of reasonable input impedance. The construction also gives a low value of lateral sensitivity with freedom from unwanted outputs caused by extraneous effects. The output of the accelerometer is linear over the acceleration range.

Each accelerometer is supplied with a 3-ft. length of special low noise cable. Longer cables may be supplied to order. Connection is made via a rugged subminiature plug and socket which effectively isolates any cable whip from being transmitted to the sensitive element. The sealed construction of the G88 permits operation in conditions of high humidity.

The G155 is a higher sensitivity version of the G88, with a lower resonant frequency of 1·5 kc/s. In all other respects, however, the accelerometers are similar. *Technical Ceramics Ltd.*, Wood Burcote Way, Towcester, Northants.

EMD 8334 for further information

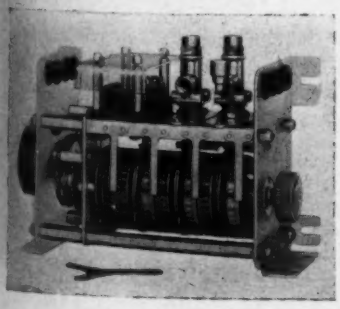
Sequence Timer

One of the most interesting features of the new "de-luxe" model Magnacam sequence timer is that it can operate directly both switches and air valves.

The Magnacam is designed to simplify greatly the automatic control of machine tools, laundry machines, chemical plants, water works, and other plant, as in addition to controlling electrical accessories such as motors and heaters the Magnacam provides direct operation of air cylinders.

The valves and switches are individually replaceable and interchangeable. The valves are three-way units with ¼ in. bore suitable for use at up to 80 p.s.i. The switches are SPDT units rated at up to 15 amps., and are complete with their own substantial screw terminals.

Each switch or valve is operated by two cams, one setting the "on" and the other the "off" points. A drum calibrated in degrees is attached to each cam and a further one gives the camshaft position. The cams are the special Rodene quick-set type which can be set quickly, precisely and permanently. They are 50% greater in circumference than those on other Rodene timers so as to allow more accurate setting, and reducing the minimum "on" time to that resulting from 4° of rotation, or, if two switches are used in series, to 1°.

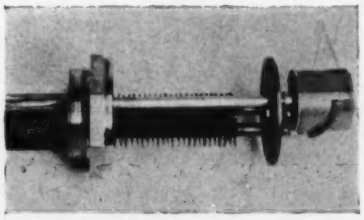


Up to twenty-four pairs of cams can be fitted, and camshaft speed ranges from one rev. in (7 seconds)×(number of cams) to about one rev. per week. The camshaft action can be forward drive with auto reset, forward drive only or if two Rodene self-clutching motors are fitted, forward and backward drive. *D. Robinson & Co. Ltd.*, 5-7 Church Road, Richmond, Surrey.

EMD 8335 for further information

Immersion Heater

A new withdrawable-type immersion heater has just been put on the market. Ceramic formers for carrying the resistance wires have been dispensed with and in place of these a magnesium oxide Eltrofin sheathed element is fitted into a pocket.



The Eltrofin heating element is said to make close contact with the pocket, thus giving a much greater transfer efficiency. A much higher loading for a given length is permissible with this type of heater and the element can be withdrawn from the pocket without having to drain the tank. As this type of element is claimed by the makers to be practically unbreakable it reduces maintenance to a minimum.

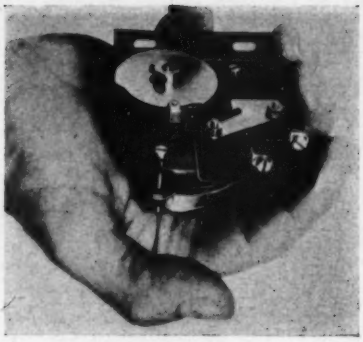
The illustration shows an oil immersion heater partly withdrawn from the pocket, and having a thermostat incorporated in a 2¼ in. B.S.P. head. *Eltron (London) Ltd.*, Accrington Works, Strathmore Road, Croydon, Surrey.

EMD 8336 for further information

Motor-driven Timer

A new miniature synchronous motor-driven timer which has just been made available has been specially designed for the quantity market where a highly competitive price is of major importance, says a statement by the makers.

Its extreme simplicity and small size are expected to make it suitable for many applications, this type being frequently essential for automatic operation of domestic oil firing equipment, vending machines, and similar appliances.



The timer can close one electrical circuit for a specified interval during a fixed continuously repeating overall timing cycle or, when initiated by external switch or push button, a fixed single cycle and stop switching action can be obtained.

The timer is of small overall dimensions (2¼×2¾ in.), is easy to fix in position, and is provided with a wide variety of available time cycles ranging from a few seconds up to 24 hours. Where the timer motor supply is the same as that of the switched load, the timer can be wired to give single cycle and stop operation.

Operating voltages for which the unit is available are 110 volts and 200/250 volts at 50 or 60 c/s. Switch ratings are 5 amps. at 250 volts a.c. or 24 volts d.c. *Electrical Remote Control Co. Ltd.*, Bush Fair, Harlow, Essex.

EMD 8337 for further information

Rechargeable Battery

Developed specially for the portable television set market are the rechargeable DEAC 12-volt batteries now being marketed in the United Kingdom designed to solve one of the major problems of portable television set manufacturers.

The 6-volt batteries, which are available in either a 4-ampere hour or a 6-ampere hour capacity, are new cells in a new form. They are extremely reliable and are guaranteed for a year or a minimum of 300 recharges, whichever is the less.

Each battery, 4-ampere-hour and 6-ampere-hour, can supply 2 ampere and 3 ampere outputs respectively for five hours of continuous use. When the portable set is plugged into the household mains supply, the batteries are automatically recharged via circuitry in the set.

The batteries are said to withstand temperatures as high as 50 deg. C. and Arctic conditions as low as −30 deg. C. with only slightly decreased capacity.

The construction is claimed to be such that the batteries are never overcharged, and gassing, swelling, obnoxious fumes, corrosive liquids and other disadvantages associated with ordinary storage batteries are entirely eliminated.

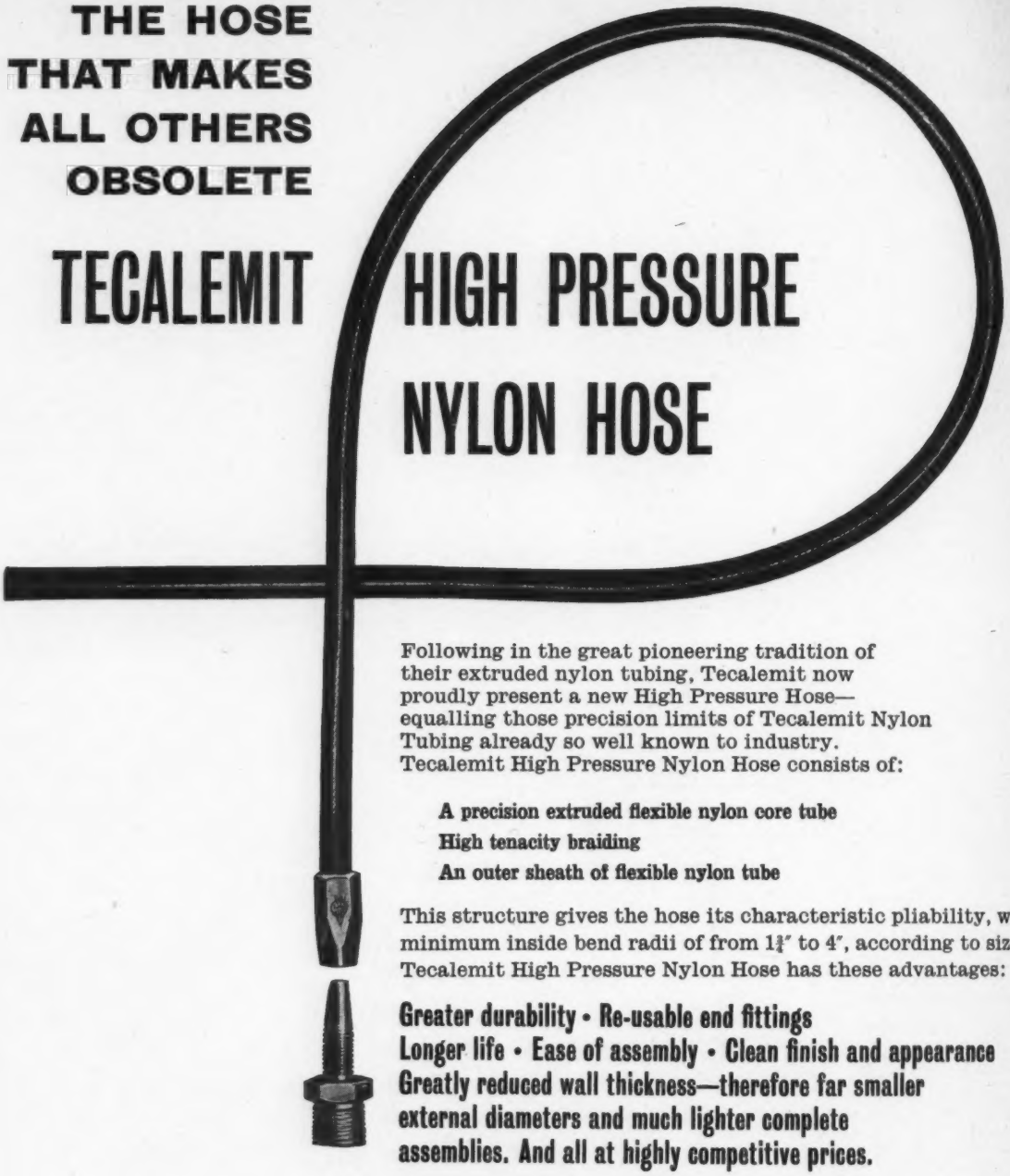
Being entirely sealed, they will work in any position—standing up, on their sides or upside-down. There are no fragile parts. They are both shock-proof and vibration proof. *G. A. Stanley Palmer & Co. Ltd.*, Maxwell House, Arundel Street, W.C.2.

EMD 8338 for further information

EMD 8240 for further information

THE HOSE THAT MAKES ALL OTHERS OBSOLETE

TECALEMIT HIGH PRESSURE NYLON HOSE



Following in the great pioneering tradition of their extruded nylon tubing, Tecalemit now proudly present a new High Pressure Hose—equalling those precision limits of Tecalemit Nylon Tubing already so well known to industry. Tecalemit High Pressure Nylon Hose consists of:

A precision extruded flexible nylon core tube

High tenacity braiding

An outer sheath of flexible nylon tube

This structure gives the hose its characteristic pliability, with minimum inside bend radii of from 1¼" to 4", according to size. Tecalemit High Pressure Nylon Hose has these advantages:

Greater durability • Re-usable end fittings Longer life • Ease of assembly • Clean finish and appearance Greatly reduced wall thickness—therefore far smaller external diameters and much lighter complete assemblies. And all at highly competitive prices.

If you wish to substantiate these claims, Tecalemit will provide sample standard lengths of hose assembled with common forms of coupling, so that test rigs can be undertaken. Tecalemit High Pressure Hose is supplied in five sizes, $\frac{1}{8}$", $\frac{3}{16}$", $\frac{1}{4}$", $\frac{3}{8}$" and $\frac{1}{2}$" internal diameter, to meet the needs of industry for hydraulic and pneumatic systems. Write for full technical details of Tecalemit High Pressure Nylon Hoses and their use on hydraulic and pneumatic systems for:—

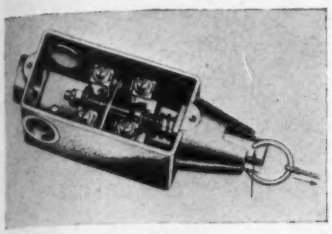
Agricultural Machinery · Earth moving Plant Mechanical Handling Plant · Machine Tools

TECALEMIT (Engineering) Ltd. (Sales EM) · Plymouth · Devon T700

WHAT'S NEW IN COMPONENTS

Fusible Link Switch

The type V/2A/P fusible link switch has been designed for use with fusible link cables on furnaces and similar equipment and is arranged for operation by tension on the switch plunger.



In the normal method of operation the cable is attached to the switch plunger by a split ring and the tension then provided by the cable ensures the switch is held in such a position that a pair of contacts is made. When the fusible link melts the cable is released and the switch plunger returned to its rest position. Two sets of contacts, one normally closed and the other open are provided, thus enabling an alarm contact to be incorporated when required. *Craig & Derricott Ltd.*, Royal Works, Coleshill Street, Sutton Coldfield.

EMD 8339 for further information

Printed Circuit Jack Socket

A new printed circuit receptacle jack designed for miniaturisation and assembly cost savings is announced by the manufacturers of Press-Fit p.t.f.e. terminals. The new SKT-111PC jack features a p.t.f.e. body and spinover mounting which provides vertical mounting on the printed circuit board.

The new jack is only 0·381 in. overall in height before spinover of mounting stud. It is designed to accept a standard 0·080 in. D probe × 0·250 in. L maximum. Overall diameter of the body is 0·218 in. Mounting is rigid and electrically sure as printed circuit board is compressed between a metal shoulder and the spinover.

The makers say that this product is ideally suited for any printed circuit or printed wiring applications which incorporate test points at various circuitry positions, or again, in modular construction in which additional external connections must be made to associated circuitry. *Sealectro Corporation*, Hersham Factory Estate, Walton-on-Thames, Surrey.

EMD 8340 for further information

Neon Indicator Units

The range of Cerberus SGF and SGFF neon indicator units are designed to operate directly on a.c. supply lines. The lamp, resistor and holder are designed in such a way that they are combined into one packaged unit. The makers say that they are particularly easy and economical to use, the unit being mounted merely by pushing into a circular hole, and then locked in position by three radial steel springs. Connection can be made with AMP-Faston type connectors, but screw connection or solder can be used if preferred.

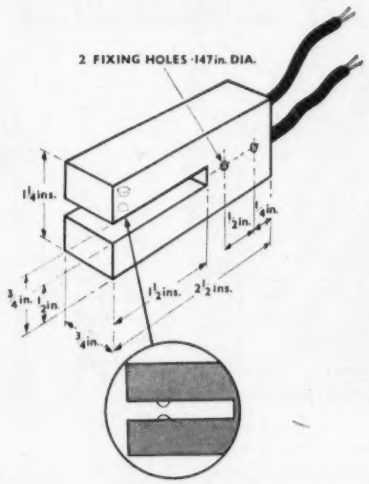
The units are marketed in a range of colours, i.e. clear, opal, red, green, yellow and blue. A life of over 50,000 hr. is claimed for them. *Walmore Electronics Ltd.*, 11-15 Betterton Street, Drury Lane, London, W.C.2.

EMD 8341 for further information

Photocell Lamp Unit

A combined photocell and lamp unit, which is suitable for use in confined spaces, is now being manufactured.

The unit, which is designated type TPR1, is claimed to be particularly suitable for monitoring on the edges of materials, discs or any thin moving objects and has applications in many industries.



The unit is 2⅞ in. long × ¾ in. wide × 1¾ in. deep and the photocell measures ¾ × ¾ × 1⅛ in.

Two fixing holes of ⅛ in. dia. are provided, and there are also two 5-ft. lengths of twin p.v.c. cable for connection to the control equipment. Both the bulb and the photocell can be changed without dismounting the unit. The bulb is rated at 6.5 volts.

This equipment is also available in two separate units—a projector and a receiver—suitable for a beam of up to 1 in. long. In all other respects it is similar to the TPR1 and is very useful where space is at a premium. *Hird-Brown Ltd.*, 244 Marsland Road, Sale, Cheshire.

EMD 8342 for further information

Co-axial Relay

Designed in conjunction with the B.B.C., the new A10 high power coaxial relay is now being generally released. The A10 is designed to handle 1 kW of R.F. power using type "C" or "N" connectors.

Contacts are of the single changeover type and of silver palladium. Coils are suitable for voltages up to 50 d.c. and characteristic impedance of 50 ohms. The V.S.W.R. is less than 1·09 and the cross talk 63 dBs down—both at 65 Mc/s. The A 10 is at present being used widely as an aerial changeover switch at unattended v.h.f. satellite transmitters. *B. & R. Relays Ltd.*, Temple Fields, Harlow, Essex.

EMD 8343 for further information

New Fleeting Contact Relay

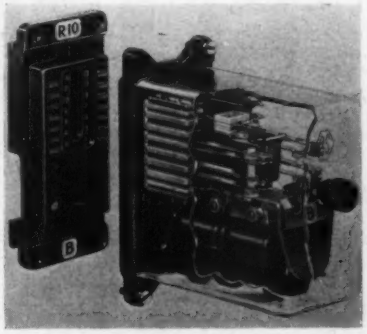
A completely new method of producing a momentary operation of one of the contacts on a relay, either when it is energised or when it is released, has been developed by Clifford & Snell Ltd. As will be seen from the accompanying illustration, a small subsidiary relay is mounted inside one of their D.2600 series plug-in relays, and this relay can be so connected that it operates for about a tenth of a second, either when the main relay is energised or when it is released, or both when it is energised and released.

This new relay has many advantages; for instance, it can be used in any position and in mobile applications such as on board ship, and the contact does not have to be normally open—it can be normally closed instead. This latter feature can be very useful as it means that the relay can be used to break the "hold" circuit of a relay or contactor, i.e. to perform the same function as the "stop" push on a contactor.

The principal application of this relay, the type D.2600/F, is in fault alarm circuits, when a fleeting contact has to cause an audible alarm to sound until manually cancelled, but it also has many applications in automatic control circuits, such as bringing up and releasing contactors and starting timers.

The illustration also shows two new features which are now standard on all new D.2600 type relays. These are, the use of Mycalex contact insulation, and a new type of base and socket which has external fixing screws, space for marking both the relay type number and the position number, and which has the numbers of the socket pins moulded on to both the back and front to facilitate the use of these sockets as test points when the relays are unplugged. *D. Robinson & Co. Ltd.*, 5-7 Church Road, Richmond, Surrey.

EMD 8344 for further information



EMD 8241 for further information

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WITHSTANDS CLIMATIC EXTREMES
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MACHINES EASILY
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WHAT'S NEW IN THE OFFICE

Office Dyeline Photocopier

The Ozaminer III, latest version of Ozalid's well known office dyeline photocopier, incorporates automatic separation of master and copy, and a speed nearly twice that of its predecessors. It uses a dry development process. The dyeline process permits the making of documents of good appearance from an original typed or written-on translucent paper.

The maximum width of "masters" accepted by Ozaminer III is 16 in., but length is limitless. It can therefore, if required, be used to make copies of small drawings and plans as well as office forms. Printing speed is up to 40 ft./min., according to the speed of the material used. In practical terms, this means up to

about twenty average-size office documents per minute. One factor which makes this high-speed production possible is a 1,200-watt light source. Automatic separation of master and copy paper also contributes to high-speed working, since it reduces manual work to a minimum. The operator merely feeds in originals and copy paper together and from then on the machine works on its own. After exposing the master and copy paper to the light source, it automatically separates and ejects the master, makes the copy and delivers it to a separate tray. As both delivery points are in front of the machine, the operator can work sitting down.

An automatic timer, calibrated in minutes, is included on the front control panel. This is set to the estimated period required for the lamp to cool, the operator then switches off the lamp and leaves the machine unattended. Complete shutdown occurs when the set period has elapsed. The Ozaminer III has a variable speed, electronically controlled. Among other advantages, this control system provides constant speed even under varying load conditions.

The machine is also available without automatic separation. Another version, identical in other respects, uses a wet development process and is also made with or without automatic separation. All are small enough to stand on an office table. *Ozalid Co. Ltd.*, Langston Road, Loughton, Essex.

EMD 8345 for further information

Coloured Stencil Sets

Rosetto inks in aerosol form are now available in black, blue, green, white, red, orange, yellow and aluminium. They are said to be particularly suitable for stencilling boxes, cartons, crates, metal drums, bales, tarpaulins, concrete, stone, etc., on porous and non-porous surfaces. The colours are claimed to be non-flaking, and to be particularly useful for colour coding on metals, steel bars or other materials for speedy identification or inspection marking. Blue ink can be used as a design layout fluid.

Advantages claimed for the ink are that it is quick drying, waterproof and weatherproof, with no waste or evaporation and no wear on the stencils. It is only necessary to shake the can and press the button. Inaccessible corners can easily be reached. *J. and H. Rosenheim & Co. Ltd.*, Barfillan Drive, Glasgow, S.W.2.

EMD 8346 for further information

Coloured Dyeline Papers

Modern drawing offices are swamped with different types of drawings. There is a need for easy segregation of the important from the routine, or to differentiate one department's work from another. Admel Ammo tinted base dyeline papers are designed to offer a simple and effective means of identification.

These ammonia developed papers are produced in four standard colours, pink, yellow, blue and green. They can be used to differentiate prototype prints from production. Contracts can each have their own colour prints. Prints of daily stock lists can have a colour to indicate a different item, i.e., steel-white, copper-yellow, etc.

These papers can be used in many ways other than the above examples and used intelligently they can greatly decrease confusion and contribute to the smooth and effective running of a modern drawing office. *Lawes Rabjohns Ltd.*, Victoria Street, London, S.W.1.

EMD 8347 for further information

Drafting Machine

A drafting machine which the makers say is as accurate as a micrometer is now being marketed by a well-known manufacturer. It is the latest in the range of Admel machines, and the extreme accuracy of the machine is attributed to a continuous driving band method of applying the four-pulley system. The makers say that the main requirement for accuracy in the pulley system is that the diameter of each pulley shall be exactly the same as that of the others, and this feature is embodied in the Admel machine by keeping the total machining limit within 0·00025 in. on all pulleys. Any possibility of slip between the driving bands and the pulleys is eliminated by an efficient tensioning system. The pulley system is also claimed to enable generous bearings to be used, thus rendering the machine virtually wear-proof and accurate throughout its life.

In the new Admel machine the protractor head is now totally enclosed and dust-proof. A new type of thumb operated protractor release control enables the head to be locked in any of the thirteen positions located at 15° intervals through an arc of 180°. The head can also be locked at any other angle by means of the intermediate head clamping lever. A head clamping lever enables the entire head to be swung round so that the scales may be lined up with any base line, and a micrometer adjustment ensures precise alignment. A built-in vernier enables scales to be set to any angle to an accuracy of 15 minutes of arc.

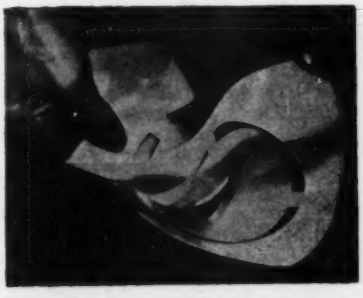
The accuracy of the head combined with that of the pulley system is claimed to be such that a line can be projected across the width of a full-size drawing board by successive instalments of the 18-in. scale, and it is said that the result will bear comparison with a line drawn against a ground steel straightedge. This test can be carried out at any angular setting. *Lawes Rabjohns Ltd.*, Victoria Street, London, S.W.1.

EMD 8348 for further information

Polythene Stencils

Per-Met stencils are manufactured from Rigidex high-density polythene sheet, designed to make them virtually indestructible, and are light in weight, free from sharp edges, and from attack by rot, rust or corrosion. Because they are translucent, alignment of the stencils is particularly simple.

They can be cut in any language, recent additions being Russian and Arabic in a variety of letter sizes. As an indication of their various applications, Per-Met



stencils have been developed for the marking of roadways, the largest size letter being 96 in. high, and the direction arrows up to 216 in. long.

With normal use Per-Met stencils are claimed to have a life of at least four times greater than conventional metal stencils, and have the useful features of being flexible enough to fit almost any contour without fear of tie-bar breakage. They can, in fact, be subjected to serious distortion and then smoothed flat again in a few seconds.

As the polythene is inert, the stencils are easily cleaned, inks are rapidly washed off and paint wiped off (or flaked off when dry). *Heller & Sons (Engineers) Ltd.*, Turnpike Lane, London, N.8.

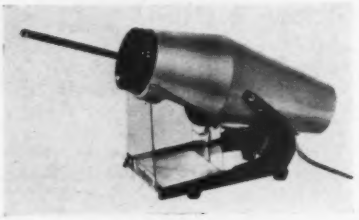
EMD 8349 for further information

WHAT'S NEW IN THE OFFICE

Mains Pencil Sharpener

A new mains-operated pencil sharpener, the Tombow, has been introduced. It is operated by simply inserting the pencil in the machine, which forms a perfect point in less than 2 sec.

The Tombow is styled to harmonise with modern office equipment, yet is



solidly constructed for heavy duty in large offices, schools, drawing offices, studios, etc. Its cast iron casing is base mounted on rubber feet and finished in translucent grey and black. It is fitted with a removable clear plastics shavings container.

The sharpener is 9×4×6½ in. high, weighs 5¼ lb., and works on 220-250 volts, 80 watts 50-60 c/s. It is supplied with 5 ft. of three-core flex. *Business Aids Ltd.*, 185 Goswell Road, London, E.C.1.

EMD 8350 for further information

Progress Chart

A special wall chart system has been devised for use by Walter Somers Ltd., of Halesowen, Worcs., to progress orders. About 300 orders for crankshafts and large forgings are progressed through six main stages and ten subsidiary stages on four charts.

The system is said to have several advantages. Foremost among these is the fact that overdue items can be found quickly, and are immediately visible. Also, the load on any one department can be easily ascertained.

Four charts comprise the system. Down the left-hand side of each chart there is a card index system. Details of each order received by the company are entered on an index card, the information including planned dates for each stage of production and, subsequently, the actual dates.

The charts used in this system are known as Movigraph Rotadate. The basis of the Movigraph system is a perforated panel—the perforations hold the various signals.

In the Rotadate method, however, there are three (or more) such panels, sliding in horizontal channelled sections. When a period covered by the first panel has ended, that panel can be removed, the remaining panels slid to the left, and a fresh panel inserted in the vacant space. Thus, any situation can be plotted for an indefinite period of time. *Adapta-Charts Ltd.*, 129 Hammersmith Road, London, W.14.

EMD 8351 for further information

Print Copier

The Speed-O-Print model 150 photocopier, which had its first showing recently at the Business Efficiency Exhibition in London, copies any mark on any type of paper, black or in colour, line or in tone. It will take documents of any width up to 15 in., of any length.

Of console design, the photocopying machine standing on its own cabinet has ample storage space for material stocks.

No mixing or filling is said to be necessary with the Speed-O-Print, ready mixed developing fluid being held in a flat plastics Readipak sac in the rear of the machine. Model 15C takes either a 48 cc. sac or a 32 cc. sac (as used in the smaller Speed-O-Print models). The developer fluid is automatically drained from the trough into airtight storage in the sac when the machine is out of use; this conserving the fluid.

Special design trigger-operated paper dispensers ensure that positive and nega-

tive papers in the required size are fed the correct way up in relation to the original being copied. Immediately above the dispensers is the feeding slot into which the negative/original/positive "sandwich" is fed. This makes operation simple and eliminates errors in feeding.

Double paper dispensers are provided on this model, the top pair of dispensers housing either 8×10 in. or 8½×11 in. papers or, alternatively, 8×13 in. or 8½×14 in. The bottom pair of dispensers is normally used to house 16 × 13 in. papers, but may, of course, be used for any width of paper up to 15 in.

Perfect copies from any original are said to be made under ordinary daylight conditions in 20 sec. *Office Mechanisation Ltd.*, Stephen Street, London, W.1.

EMD 8352 for further information

Drafting Paper

Ozavel-D is claimed to be a major break-through in paper treatment and finishing techniques. It is said to be an entirely new approach both in the method of "transparentising" and in the treatment of both sides of the paper to produce superfine drawing surfaces. Tough, tear-resistant, all-rag base paper is treated by new methods to give high transparency, a clear white appearance and colour retention qualities that will withstand years of storage. The base is then given further treatment on both sides to produce perfect, durable surfaces for both pencil and ink working.

These new techniques are claimed to give Ozavel-D several advantages, i.e. (a) toughness and tear resistance, with improved handling and storage qualities, (b) will not yellow or brittle with age, (c) clear white appearance for easy drafting with high transparency for fast tracing and high speed reproduction, (d) both surfaces have a fine pencil "tooth" that ensures even thickness and density of line, (e) both surfaces accept ink without "feathering" or thickening of line, (f) both surfaces will withstand repeated pencil or ink erasures without damage or leaving a "ghost" image, and (g) lines will not wear or crack from the paper.

Ozavel-D is available in rolls or cut sheets, plain or pre-printed. *Ozalid Co. Ltd.*, Langston Road, Loughton, Essex.

EMD 8353 for further information

Self-adhering Lettering

Transparent, self-adhering, printed acetate sheets of alphabets, numbers, arrows, symbols, borders, shading mediums and other designs marketed under the name of Artype are now available in Britain, although they have been used extensively in the past in the U.S.A.

The sheets measure 10×14 in. overall and each sheet is a complete unit in itself with all letters of the alphabet repeated in the frequency most generally needed, or as in the case of the numbers, arrows, symbols, borders, screens and shading mediums, as many as space permits.

The sheets of letters make it possible to eliminate a vast amount of hand lettering work. The letters or symbols are simply cut from the sheet with a stylus blade and transferred to the work-sheet and positioned by means of a simple system of guide lines. The letters are self-adhesive, so that when the backing paper is removed they need only to be pressed down to the paper with a blunt burnishing stick. The guide lines are then easily removed and the completed word or pattern is firmly fixed in place. The sheets can be used for a variety of jobs because they adhere to any smooth surface—paper, wood, metal or glass. As the printing is on the underside of the acetate sheet, there is no danger of the letters becoming smudged. Some 100 and more different type faces in large and small sizes are represented in the range of sheets that are available. *Hunter-Penrose Ltd.*, 109 Farringdon Street, E.C.1.

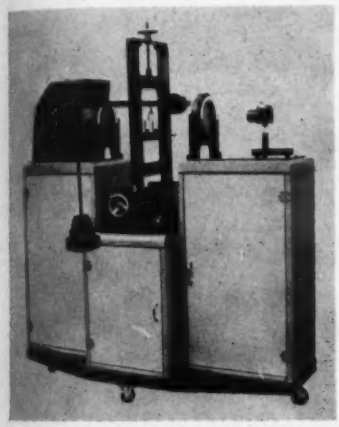
EMD 8354 for further information

WHAT'S NEW IN EQUIPMENT

Dual-purpose Polariscope

The Sharples 5½-in. dia. polariscope is claimed to be unique in that provision is made for using it either as a diffused light or as a transmission instrument. When set up for use with diffused light, a 60-W. sodium vapour lamp is used in conjunction with two 150-W. tungsten filament lamps for white light illumination, both types of lamp being contained in a detachable lamp-house. To prevent on-and-off switching of the sodium lamp, a rotatable shield is provided.

To convert the diffused light polariscope into a transmission type, it is only necessary to replace the existing lamp-house with a special platform which carries a 250 W. compact source mercury vapour lamp, a 150 W. tungsten filament lamp and a 6-in. dia. condenser lens of optical quality. The tungsten filament lamp can be brought into use by switching on and swivelling a mirror into position which then has the dual purpose of directing the white light through the condenser lens and at the same time screening off light from the mercury vapour lamp. At the other end of the polariscope, a sliding bellows mounting is provided to carry the camera lens which then serves as a projection lens. A glass screen to accept tracing paper is fitted to receive the projected image.

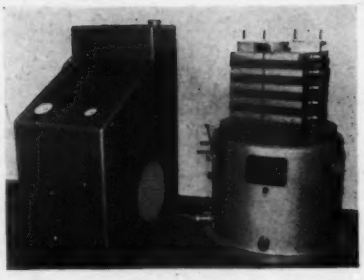


Loading is normally through a lever and dead weight system, tensile compressive, flexural and torsional loads being conveniently applicable. *Sharples Engineering Co. (Bamber Bridge) Ltd.*, Hillcrest Works, Chorley Road, Walton-le-Dale, Preston, Lancs.

EMD 8355 for further information

Hydraulic Vibration Generator

For applications in the aircraft, automobile, ship-building, civil construction and heavy engineering industries there is a need for a machine which will vibrate a wing, or a motor-car's suspension or a sample of metal to test its resonance and, if necessary, fatigue it until it breaks. The requirement at its simplest is for something which will generate a large thrust at frequencies right down to nil c/s over a long stroke. Fairey Air Surveys' Research and Engineering Division has developed a new piece of equipment to meet it.



This new unit has a 2,000 lb. thrust with a working range of 0 to 50 c/s and a maximum stroke of 4 in. at the lowest frequencies. Both frequency and amplitude are remotely controlled from a power console, and may be varied while the equipment is running. The vibrator unit uses a hydraulic jack actuated by an electrically-signalled valve, and is connected to the control unit/power pack by two high-pressure hydraulic lines and one electric control cable. The equipment is supplied complete, and no further amplifiers, oscillators or output transformers are necessary. The vibrator itself weighs 1,100 lb. and the control unit/power pack 600 lb. The power requirement is 4½ kW. at 440 volts 3 phase 50 c/s a.c. supply.

The equipment's ability to maintain a dynamic thrust of 2,000 lb. over the full frequency range of 0-50 c/s means that it is capable of vibrating an item of this weight fixed to the table top, and that it can also exert this load onto an existing structure (such as a high-set tailplane) through appropriate linkage rods. *Fairey Air Surveys Ltd.*, 24 Bruton Street, London, W.1.

EMD 8356 for further information

New Publications and Technical Literature

Powder Metallurgy Ltd.: 27-page booklet describing the company's range of metal powders. Berk House, 8 Baker Street, London, W.1.

EMD 8357 for further information

Midland Silicones Ltd.: 20-page illustrated brochure describing the principal ways in which silicones can be used in the engineering and allied industries, with examples and illustrations from current industrial practice. 68 Knightsbridge, London, S.W.1.

EMD 8358 for further information

Delaney Gallay Ltd.: Two leaflets: *Vibrashock Isolation*, describing the company's new all-metal anti-vibration mountings; and *Metal-joining Heat-treatment*, dealing with the company's metal-joining service. Vulcan Works, Edgware Road, Cricklewood, London, N.W.2.

EMD 8359 for further information

Metal Sections Ltd.: 8-page brochure on Metsec Helitube, which is a lightweight metal tubing of spiral construction available in a variety of metals. Oldbury, Birmingham.

EMD 8360 for further information

William Rose Ltd.: 6-page brochure dealing with Hilflon p.t.f.e. flexible hose. Hilyn Works, Lockfield Avenue, Brimsdown, Enfield, Middlesex.

EMD 8361 for further information

Imperial Chemical Industries Ltd.: 18-page well-illustrated brochure describing Terylene reinforced industrial hose. Millbank, London, S.W.1.

EMD 8362 for further information

The Brooke Tool Manufacturing Co. Ltd.: 34-page well-produced brochure on the company's range of gear pumps. Warwick Road, Birmingham 11.

EMD 8363 for further information

Desoutter Brothers Ltd.: 24-page well-illustrated catalogue of the firm's standardised die sets. Die Set Division, 121 Hay Lane, Kingsbury, London, N.W.9.

EMD 8364 for further information

Lead Development Association: 16-page illustrated booklet entitled *Production Properties and Uses of Lead Cable Sheathing*. 34 Berkeley Square, W.1.

EMD 8365 for further information

Bakelite Ltd.: a new edition of *Bakelite Laminated for Gears*, a 20-page illustrated brochure giving applications, installation principles and all relevant formulae and data. 12-18 Grosvenor Gardens, London, S.W.1.

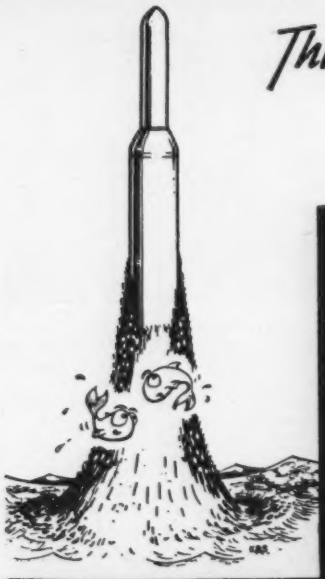
EMD 8366 for further information

British Resin Products Ltd.: *Cellobond Polyester Resins*, a well-produced 230-page handbook fully describing the properties and methods of fabrication of these materials; *The Cellobond Polyester Story*, a 24-page well-illustrated booklet on the manufacture of polyester-glass laminates, with many examples of the latest applications of the resin bonding technique. Devonshire House, Piccadilly, London, W.1.

EMD 8367 for further information

English Steel Corporation Ltd.: 60-page revised and enlarged edition of a pocket-book giving useful information on the care and use of E.S.C. engineers' cutting tools. P.O. Box 57, River Don Works, Sheffield 9.

EMD 8368 for further information



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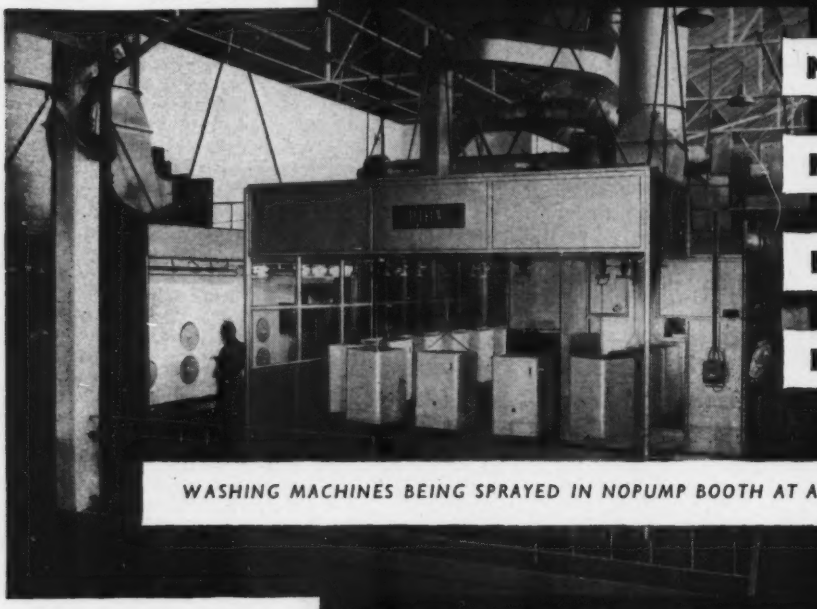
BULLOWS NOPUMP SPRAY BOOTH

In this new type of Water-Wash Spray Booth the exhaust air travels at very high velocity over the water surface entraining water. The air/water mixture, moving through controlled changes of direction, provides the scrubbing action.



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News of Industry

Cutting by Liquids

The first production model of a "liquid lathe" for cutting material was demonstrated recently in the U.S.A. The lathe delivers a needle point of liquid under extremely high pressure which is able to cut, among other materials, cement, wood and plastics. The liquid cutting process was invented by North American Aviation as part of a research programme to find tools and processes for shaping and forming materials for advanced aerospace craft.

An immediate application for the idea was found in the safe removal of high energy solid propellant materials from engine casings, the first liquid lathe being developed by *Abrasi-Jet Machine Tool Corp.* especially for this duty.

Analogue Digital Converters

Elliott Bros. (London) Ltd. are now able to supply the range of Datex analogue digital converters and associated units, some of which are already in production. These devices are used in data-handling applications in ground and air navigational systems and throughout the industrial process control field. Applications fall into three main groups: data acquisition and data reduction, measuring position co-ordinates for navigation, and measuring position co-ordinates for machine control.

Datex encoding units are rotary-pattern, coded-type commutators which convert angular position co-ordinates into digital electrical signals. The auxiliary equipment is designed to accept the coded output of the digitiser and convert it into suitable form for display, recording or further processing. These units can be either electro-mechanical or electronic devices. The output normally takes the form of a digital (decimal) lampbank display, printed records, paper tape or punched cards.

Cargo Handling

A demonstration of the Rolamat cargo-handling system was recently given at Aberystwyth, sponsored by the Welsh Agricultural Organisation Society, in conjunction with *Sir W. G. Armstrong Whitworth Aircraft Ltd.* Rolamat was originally developed by Armstrong Whitworth for loading and unloading Argosy aircraft.

The Welsh agricultural group have devised a system by which a truck fitted with Rolamat can discharge its empty body on to an unloading bay, take on a new loaded body and be out on the road again in a quick turn-round. The bay is, in fact, now able to handle ten vehicles in the time formerly taken for one.

Because of the layout of this particular loading station, it is necessary to use side-loading, but in many cases rear loading would be possible.

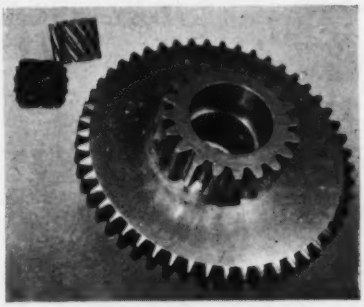
The truck, complete with empty pallet, drives into the unloading bay, the pallet is pulled off by hand leaving the truck ready to receive a loaded pallet. The pre-loaded pallet is winched on and locked in place by means of clamps.

Vibrafinishing Machine

A semi-automatic Vibra finishing machine for the batch deburring of machined steel components has been built by *Roto-Finish Ltd.* The machine has an adjustable process cycle of 0-4 hr. which can be pre-set by a timer. Capacity is 1,600 components per cycle.

The basic parts of the machine consist of a vibrator tub, two bucket conveyor belts, a magnetic separator, and a compound storage tank with pumps. Vibration is generated by out of balance weights at either end of a motor, specially designed by the English Electric Co. Ltd. The motor is attached to the bottom of the tub.

The company is well advanced with the development of a continuous feed Vibrafinishing machine. In essence this machine consists of two work tubs in parallel (both



tubs being fitted with a scroll form), two conveyor belts, one at each end of the work tubs, to convey material from one tub to the other.

In operation processing compound is constantly circulated through the tubs by means of pressure pumps from two storage tanks, these being separate, two different processes can be carried out in the two tubs, for example, the first tub can deburr and the second tub polish.

The machine at present under development has been designed for a relatively short process cycle time of approximately 15 min., and to take work parts of a maximum size of three-inch cube. The total capacity of the two tubs is 20 cu. ft. of mixed work and processing media.

Typical components finished by this process are illustrated above.

Fuel Waste Burner

Thermal vortex burners are now being manufactured in this country by *Thermic Equipment & Engineering Co. Ltd.* They operate upon a wide range of residual fuels and waste products, including light oils, asphalts, residua, acid sludges, solvents, or any gas. Changing over fuel without shutting down or simultaneous firing of oil and gas is possible.

Essentially the vortex burner consists of an air swirl-vane assembly chamber. Combustion is rapid and clean, about 80% occurring within the burner and resulting in a very short, whirling, hot (1,650 deg. C.) flame extending only 1 or 2 ft. from its mouth; no external combustion chamber or furnace is required.

Conventional fuel and air pressures are used (140 p.s.i.g. oil, less than 1 p.s.i.g. air) and normal use requires 5% excess air, but the burner is capable of accepting between 70 and 300% of stoichiometric air without resultant soot or flame failure. Igntion is by gas-electric pilot burner and there is provision for flame failure equipment.

The burner's short flame length and 100 ft./sec. velocity improve convection heat transfer and stir up furnace gases, making it particularly useful for oil stills and packaged direct-fired air heaters. Designed to complement the burner the air heaters are extremely compact and incorporate no refractory lining.

Heavy-duty Compressors

A new range of compact, heavy duty, water cooled, double acting, crosshead type, stationary air compressors, in which the cylinders are set 90° apart, has been introduced by the *Consolidated Pneumatic Tool Co. Ltd.*

The new range, known as the Y class, is available in seven sizes with outputs of from 372 to 1,615 c.f.m., at pressures of from 80-125 p.s.i., the horsepower range covered being from 75 to 300 b.h.p. Multi-stage units are available for pressures of up to 3,000 p.s.i. The compressor can be driven by a flange mounted motor, vee-belt driven or by a direct coupled motor.

New Outboard Motors

An entirely new, all British range of five outboard motors suitable for all types of craft from little dinghies to big cabin cruisers are being marketed by the *Perkins Group.*

They range from a new 40-h.p. motor, claimed to be so silent that it will set new standards for this type of engine, to a 4½-h.p. motor.

A feature of the new model is a sealed power head suspended on rubber mountings to prevent vibration and noise, and an improved, downward-directed silencing system.

The power unit is fitted with poppet valves to give relatively high torque at low operating r.p.m., increasing thrust and providing good acceleration.

Stainless steel parts have been used throughout the motor. Valve guide bosses are fitted with inserts to give longer life and the general surface finish of all working parts, including crank journals, cams, cam followers and valve stem tips, is of very high standard.

Available with manual or electric starting, the electric starting motor has a magneto-alternator fitted as standard equipment for battery charging.

The throttle and gear shift remote control system are concealed beneath the one-piece glass fibre reinforced plastics top shroud.

Leak Detection Service

Spembly Ltd. now offer a leak testing service, equally applicable to vacuum and pressure vessels, using mass spectrometer techniques.

In pressure vessel work, vacuum testing is invaluable as a preliminary to pressure testing as, by using a light gas, defects in welds and porosity etc., are much more readily located than when liquid is used. In addition the metal remains uncontaminated thus making rectification easier.

Hydrogen is used in these tests, the size of the leak detectable being of the order of one part of hydrogen in ten million parts of air.

Stress-relieving Furnace

Head Wrightson Teesdale Ltd. are installing an electric stress relieving furnace measuring 27 × 27 × 80 ft. at their Thornaby-on-Tees works. This furnace is capable of stress relieving large fabrications such as oxygen steel converters and will be used in the fabrication of the boilers for the nuclear power station at Dungeness.

Designed by *Cooper Electroheat Ltd.*, an important feature is that no firebrick is used anywhere in the furnace. The actual construction of the furnace is being carried out by Head Wrightson and although the furnace is not yet complete, it has already been used for stress relieving fabrications weighing 50 tons.

The hearth, walls and roof are constructed generally from 8×8 ft. mild steel panels which are filled with compressed mineral wool slabs and secured with flexible mild steel sheeting.

The side walls, carried by A-frames and mounted on bogies, are retractable. The end walls can be lifted into position in two sections by means of a mobile crane.

Arranged in 40 kW units, are 1,500 kW electrical elements, at mains voltage, each unit comprising twelve coiled elements in sintered alumina sleeves supported in stainless steel channels. The channels rest on mild steel framework which is placed on the floor of the furnace.

A 40-ft. length of the furnace is now completed and in this section a fabrication was stress relieved within limits of 610 deg. C. minimum and 630 deg. C. maximum.

The Lapmaster

The new 72-in. Lapmaster—the largest lapping machine in Europe—is shown here in operation at the Slough works of *Payne Products International*. The maintenance of this machine, and for all models in the Lapmaster range, is extremely simple. The conditioning rings riding upon the lap plate

recondition the plate while lapping is in progress. For this reason it is only necessary to remove the lap plate after several years wear.

Reversible Pump/Turbine Unit

A major development in water-power engineering has been achieved by *Boving & Co. Ltd.* with the design of reversible pump/turbine units. Boving have been awarded a contract for two units operating under a total gross head of 1,196 ft. at the Cruchan storage plant, in Scotland; these units will have the highest power output in Europe. This is the first time that reversible pump/turbines have been designed for such a high head.

When drawing water from the upper reservoir and operating as a turbine, each unit will develop 140,000 h.p.; operating in the reverse direction, as a pump drawing water, each unit will absorb 150,000 h.p. and deliver 30 tons/sec. into the upper reservoir.

I'm suffering from a dropped forging.

Sawmill Automation

Thomas Robinson & Son Ltd. and *R. H. Buckley*, have together pioneered the design and installation of the first successful automated timber-yard bogie/cross-cut/moulder transfer line in the U.K. Coupled with lower labour costs, this type of equipment, having a considerably high production potential than conventional cross-cutting equipment, is likely to soon become an essential part of all modern sawing, planing and joinery plants. A model and a modified working version will be exhibited for the first time in this country at the Building Exhibition, in November.

The whole transfer line, controlled by one man, is for the continuous production of cross-cut and moulded stock from random-length unplaned timbers. It consists of a travelling, tilting unloader hoist, and hydraulic cross-cut saw with mechanised tables and remotely-controlled stops, together with the necessary conveyors, etc., connecting the hoist at the infeed end with the moulder at the outfeed end.

The conveyors may be arranged to feed round a bend, or in a straight line into the moulder. Alternatively, when the cross cut is required to feed more than one machine, a second route, together with the necessary selector gates, etc., can be provided. In a similar way escape points and reserve storage can be arranged, so that the production of one machine is not held up by the temporary stoppage of the preceding or following machine. The controls for the cross-cut saw, length-gauging stops, conveyors and tilting hoist are conveniently grouped at the front of the cross-cut saw, and are thus within easy reach of the operator.

Meetings

In the week May 2-11, 1962, the joint exhibitions Power Generation and Space Research and Technology, sponsored by the *Institute of Fuel Technology* and the *British Interplanetary Society* respectively, will be held at Olympia, London.

The *Institution of Electrical Engineers* and the *Royal Aeronautical Society* are holding a conference in London on February 26-28, 1962, on The Importance of Electricity in the Control of Aircraft. A very wide range of subjects of interest to aircraft and equipment designers will be presented in some thirty or forty papers.

Martonair Ltd. are sponsoring a series of five-day courses entitled Course in Applied Pneumatics, the first of which was held at Farnham, Surrey, during October. Further courses are being arranged to commence on March 5 and 26, 1962, and on April 16, 1962; vacancies exist only on the last date mentioned.

New Film

A new colour film running for 35 min. has been produced by the *United Kingdom Atomic Energy Authority*. Entitled *Nuclear Power Reactors*, it surveys, largely by the use of animated sequences, the working of a number of different successful reactor systems.

ISOPAD LTD.

ELECTRIC HEATING TAPES

END 8243 for further information

Engineering Materials and Design

DATA SHEET MFG/2—C

Isotapes consist of an insulated resistance element fitted to a flexible electrically insulating base forming a complete heating circuit terminating at one end. The material to which the heating element is fitted varies with temperature and duty. Apart from their flexibility, the great advantage of Isotapes lies in their ease of application and robust construction. Various types have been developed to deal with different applications and working conditions.

ITA Heating Elements fully electrically insulated (moisture repellent but not moistureproof) attached to robust Isopad glass weave. For compensating and heating duties up to 350°C. (662°F.). Up to 9 ft. long, 1 in. wide; longer tapes 1½ in. wide.

Dimensions		Approx. 10 watts per ft.	Approx. 15 watts per ft.	Approx. 20 watts per ft.	Price
ft.	m.	watts	watts	watts	£ s. d.
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6	1·8	—	90	150	2 15 0
9	2·7	100	130	200	4 0 0
12	3·6	120	180	260	5 0 0
15	4·5	150	240	320	7 0 0
20	6	200	310	450	9 0 0
25	7·5	250	375	530	11 0 0
30	9	300	450	750	12 0 0
40	12	410	600	880	15 0 0
50	15	500	730	1,030	18 0 0
60	18	600	900	1,200	20 0 0
70	21	700	1,050	1,400	22 0 0
80	24	800	1,150	—	25 0 0
90	27	—	*1,400	*1,900	30 0 0
100	30	950	*1,500	*2,000	35 0 0
120	36	*1,200	*1,600	*2,800	42 0 0
140	42	*1,400	*2,300	*3,000	49 0 0
150	45	—	*2,200	—	53 0 0
180	55	*1,800	*2,500	—	63 0 0
200	61	*2,200	—	—	70 0 0

*For explanation see next page.

ITH HIGH POWER
Element temperatures up to 425°C. (800°F.). 1 in. (2½ cm.) wide

Dimensions		watts	ITH/45
ft.	m.		£ s. d.
1½	0·45	65	1 15 0
3	0·9	140	2 10 0
6	1·8	250	3 0 0
9	2·7	400	5 10 0
12	3·6	500	8 0 0
15	4·5	600	10 0 0
20	6·0	900	13 0 0
24	7·3	1,000	15 0 0
28	8·5	1,100	17 0 0
33	10·0	1,350	20 0 0

ITQ HIGH TEMPERATURE
Using quartz cloth material for element temperatures up to 800°C. (1,472°F.). 1 in. (2½ cm.) wide

ITQ/45	ITQ/70			
	Dimensions		watts	Price
£ s. d.	ft. in.	m.		£ s. d.
2 10 0	—	—	—	—
3 15 0	5 0	1·5	350	5 10 0
5 10 0	—	—	—	—
8 10 0	7 6	2·3	480	8 10 0
12 10 0	9 0	2·7	650	10 10 0
15 0 0	12 0	3·6	800	14 0 0
20 0 0	13 4	4·0	900	16 0 0
24 0 0	15 10	4·7	1,100	18 0 0
26 0 0	22 0	6·7	1,400	24 0 0
30 0 0	25 0	7·5	1,750	28 0 0

ITX (P.V.C. extruded) weatherproof for frost protection and low-temperature heating duties. Maximum element temperature 70°C. (158°F.). ⅜ in. (1½ cm.) wide

ITX/5					ITX/3½				ITX/110V				ITX/50V			
ft.	in.	m.	watts	£ s. d.	ft.	in.	watts	£ s. d.	ft.	in.	watts	£ s. d.	ft.	in.	watts	£ s. d.
8	4	2·5	50	1 15 0	12	0	40	2 0 0	4	2	30	1 0 0	—		—	—
16	8	5	90	3 10 0	20	0	75	4 0 0	8	4	40	1 15 0	4	2	20	1 0 0
33	4	10	170	6 15 0	40	0	140	7 10 0	16	8	75	3 10 0	8	4	35	1 15 0
50	0	15	250	10 10 0	60	0	200	12 0 0	25	0	115	5 5 0	12	6	55	2 10 0
75	0	22·5	375	15 0 0	90	0	300	18 0 0	37	6	180	7 10 0	16	8	80	3 10 0
100	0	30	500	20 0 0	120	0	410	24 0 0	50	0	230	10 10 0	25	0	110	5 5 0
140	0	43	700	30 0 0	166	8	600	35 0 0	66	8	310	14 0 0	33	4	150	6 15 0
241	8	73	1,150	45 0 0	292	6	920	60 0 0	116	8	550	24 0 0	58	4	260	12 0 0

FLAMEPROOF (AND WEATHERPROOF) ISOTAPES

Heating Elements metal sheathed and magnesia insulated fitted to robust Isopad glass weave terminating in ¾ in. flameproof glands; suitable for use in flameproof areas Group II and III whereby the user must keep the temperature of the heating element below the spontaneous ignition point of explosive gases present

FTA/CN for element temperatures up to 300°C. (572°F.). 2 in. (5 cm.) wide

Dimensions		Watts per ft. (approx.)						Price
ft.	m.	5	10	15	20	30	Volts	£ s. d.
6	1·8	—	65	—	120	160		6 0 0
9	2·7	50	80	150	—	250	25	8 0 0
12	3·6	60	110	180	220	—		10 0 0
12	3·6		140	—	250	—		10 0 0
15	4·5	95	200	280	380	550	50	12 0 0
20	6·0	150	210	300	400	560		15 0 0
25	7·5	125	240	350	450	600		18 0 0
25	7·5	—	—	350	—	—		18 0 0
30	9·0	190	290	—	—	—	110	21 0 0
30	9·0	—	280	480	630	900		21 0 0
40	12·0	210	390	700	950	—		27 0 0
40	12·0	—	—	—	950	—		27 0 0
50	15·0	290	590	800	—	—		33 0 0
50	15·0	—	—	750	—	1,350		39 0 0
60	18·0	320	700	1,100	1,500	2,100	240	45 0 0
60	18·0	—	620	—	—	—		45 0 0
70	21·0	400	550	980	1,350	1,800		51 0 0
80	24·0	500	850	1,100	1,550	2,400		51 0 0
100	30·5	660	900	1,350	2,000	2,600		63 0 0
120	36·5	700	1,150	1,600	2,200	—		75 0 0
140	43·0	600	1,500	1,800	—	—		87 0 0

FTA/S stainless steel sheathed elements for temperatures up to 425°C. (800°F.). 2 in. (5 cm.) wide

Dimensions		Watts per ft. (approx.)					Price
ft.	m.	/10	/15	20/30	33/45	Volts	£ s. d.
6	1·8	—	—	125	200	50	9 0 0
9	2·7	90	140	—	—		12 0 0
12	3·6	100	—	280	450	110	15 0 0
15	4·5	—	230	380	—		18 0 0
20	6·0	170	280	—	720	240	24 0 0
22½	6·8	250	—	660	1,150		27 0 0
25	7·5	220	—	600	1,050		30 0 0
27½	8·4	—	—	560	1,000		33 0 0
30	9·1	—	520	—	900		36 0 0
35	10·6	420	—	750	—		42 0 0

Please note: wattages between stepped lines denote that the relevant Isotape is at the voltage shown in the column preceding prices.

FTA/SS stainless steel sheathed heating elements mounted on stainless steel mesh. Types and dimensions as Type FTA/S. Prices plus 25% of FTA/S prices.

ITW Weatherproof, silicone rubber sheathed elements attached to robust Isopad glass weave. Temperature range—100 to +220°C. (—150 to +428°F.). Up to 9 ft. long, 1 in. wide; longer tapes 1½ in. wide

Dimensions		Approx. 5 watts per ft.	Approx. 10 watts per ft.	Approx. 15 watts per ft.	Price
ft.	m.	watts	watts	watts	£ s. d.
3	0·9	—	—	45	2 5 0
6	1·8	—	—	90	3 5 0
9	2·7	55	**95**	120	5 0 0
12	3·6	75	**120**	180	6 0 0
15	4·5	75	**150**	230	8 0 0
20	6	110	**180**	300	10 10 0
25	7·5	145	**250**	340	12 10 0
30	9	190	**300**	440	14 0 0
40	12	220	**400**	600	17 10 0
50	15	260	**500**	720	21 0 0
60	18	270	**600**	900	23 10 0
70	21	350	**720**	1,000	26 0 0
80	24	400	**850**	1,200	29 0 0
90	27	450	**800**	*1,200	34 0 0
100	30	500	***1,000**	*1,500	39 0 0
120	36	600	***1,200**	*1,600	48 0 0
130	40	700	***1,500**	*1,800	52 0 0
140	42	*850	***1,350**	*1,700	56 0 0
150	45	*1,100	***1,600**	—	60 0 0

Watts printed bold indicate Isotapes usually in stock.

* Isotapes marked with an asterisk use nickel wire as the heating element—due to its high temperature co-efficient, this wire is self compensating. Wattages shown are taken at 50°C. (122°F.). At 10°C. (50°F.) they will be 15% higher, at 90°C. (194°F.), 15% lower—recommended only for temperatures up to 100°C. (212°F.).

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Type		ITX	ITA	ITW	ITH	FTA/CN	FTA/S
Price per 100 ft.	300–1,000	£ 18	£ 30	£ 35	£ 50	£ 60	£ 110
	1,000–3,000	16	26	30	46	52	100

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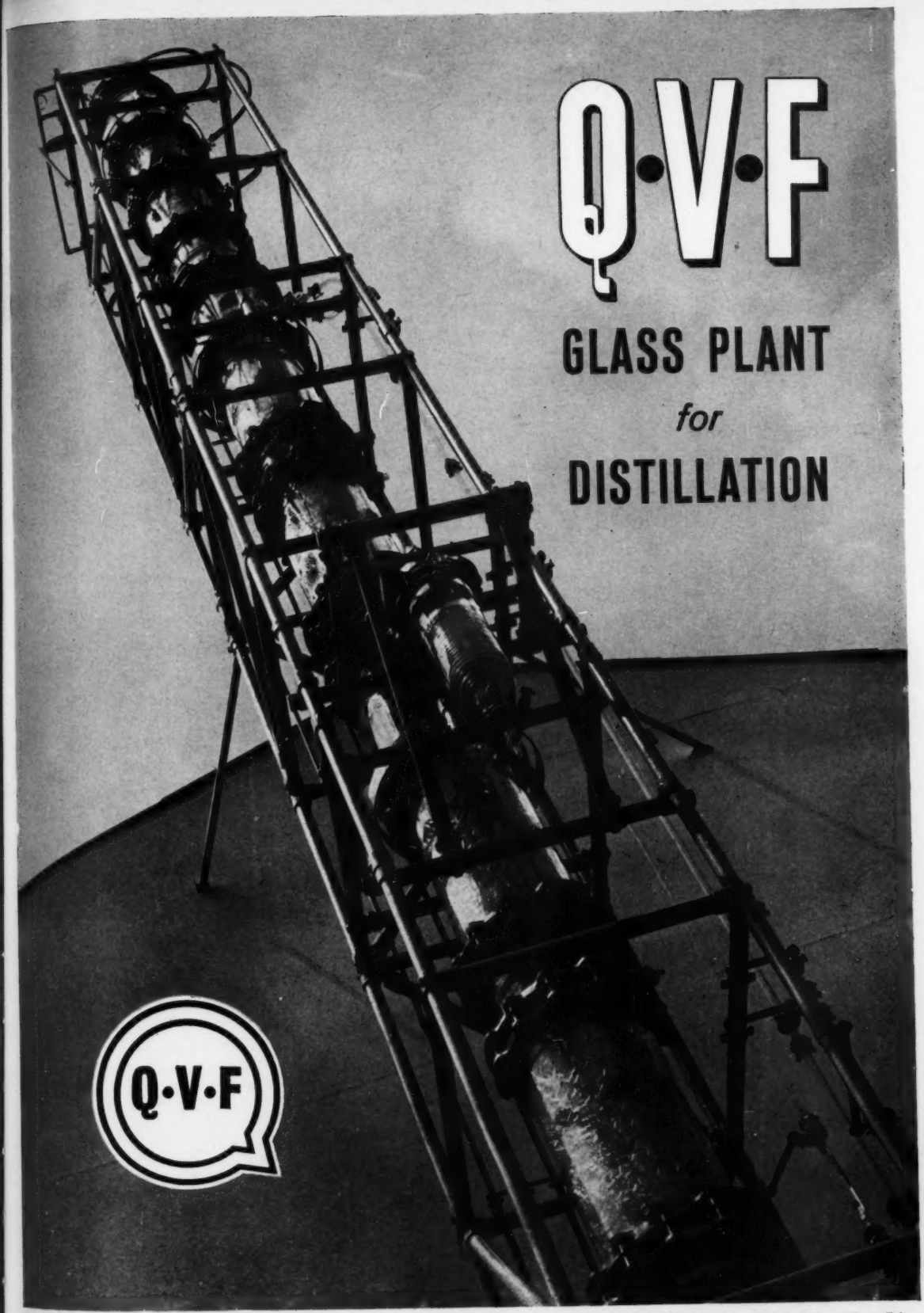

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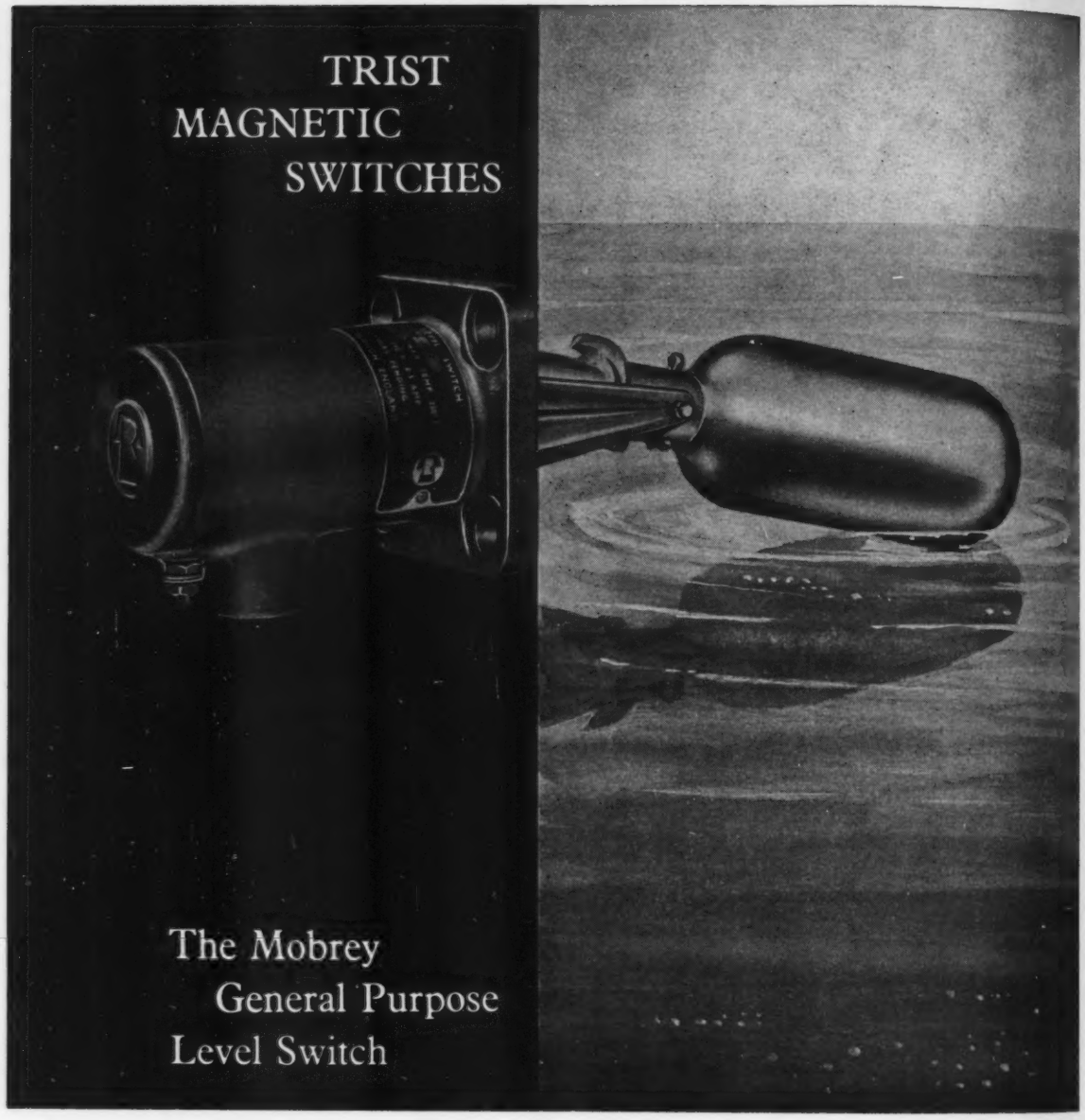

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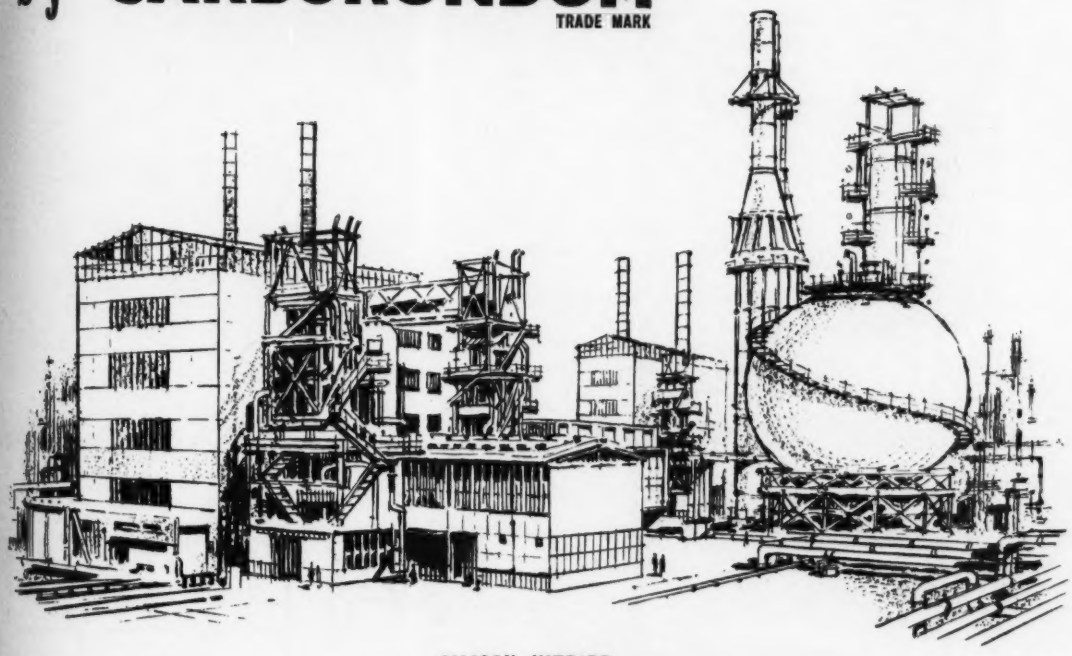

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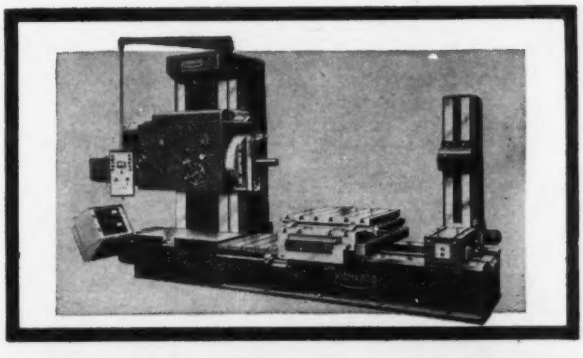

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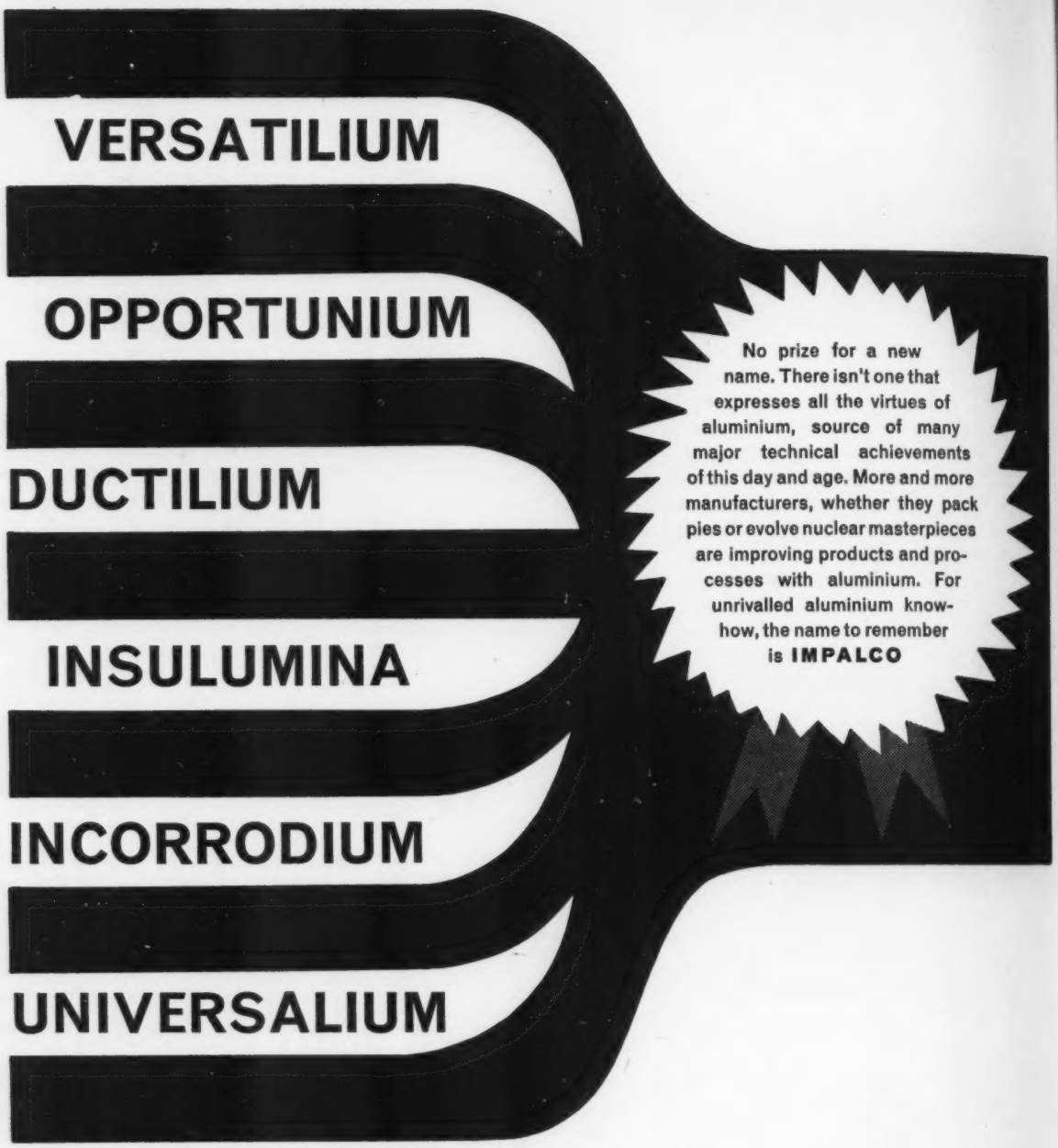
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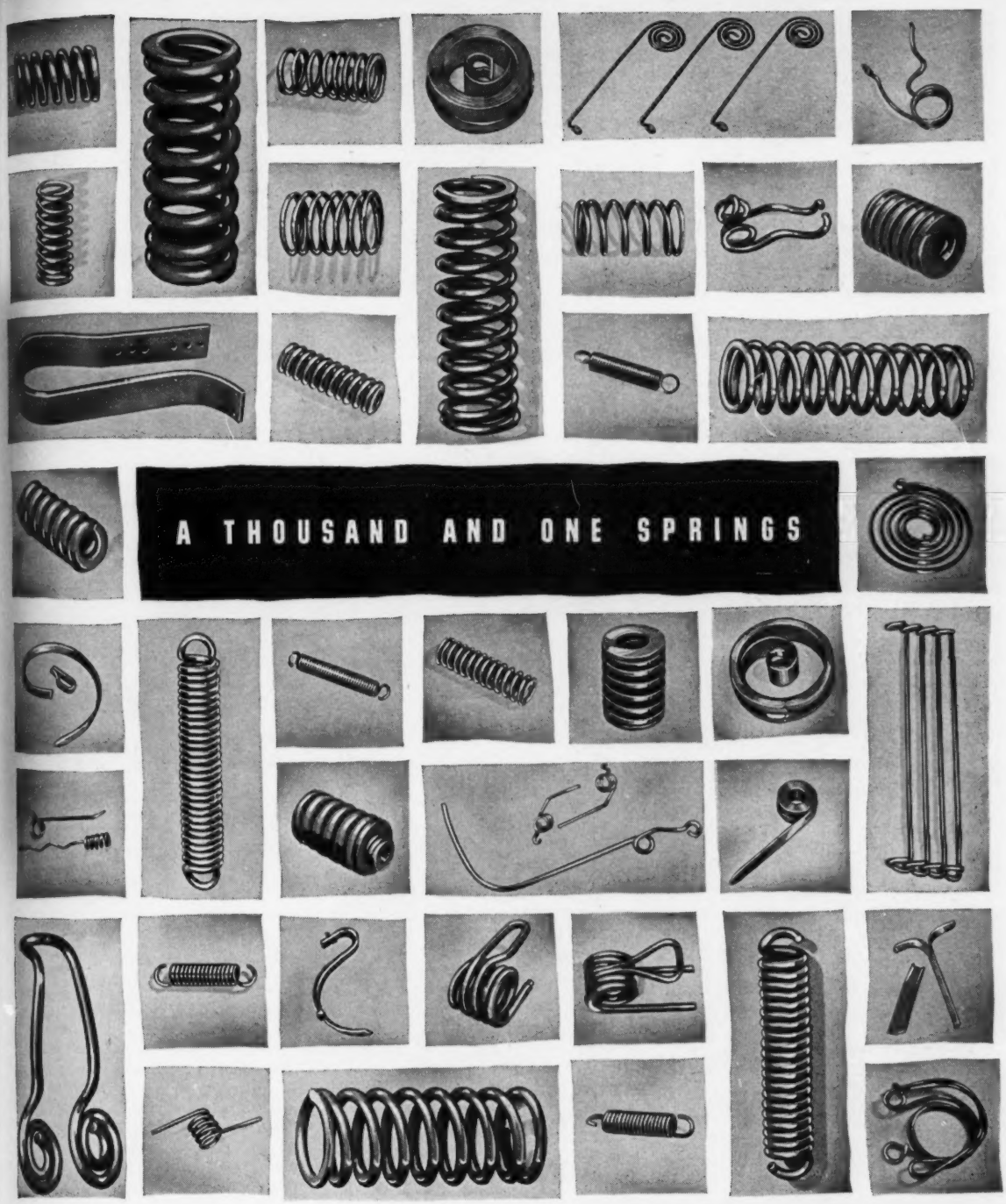

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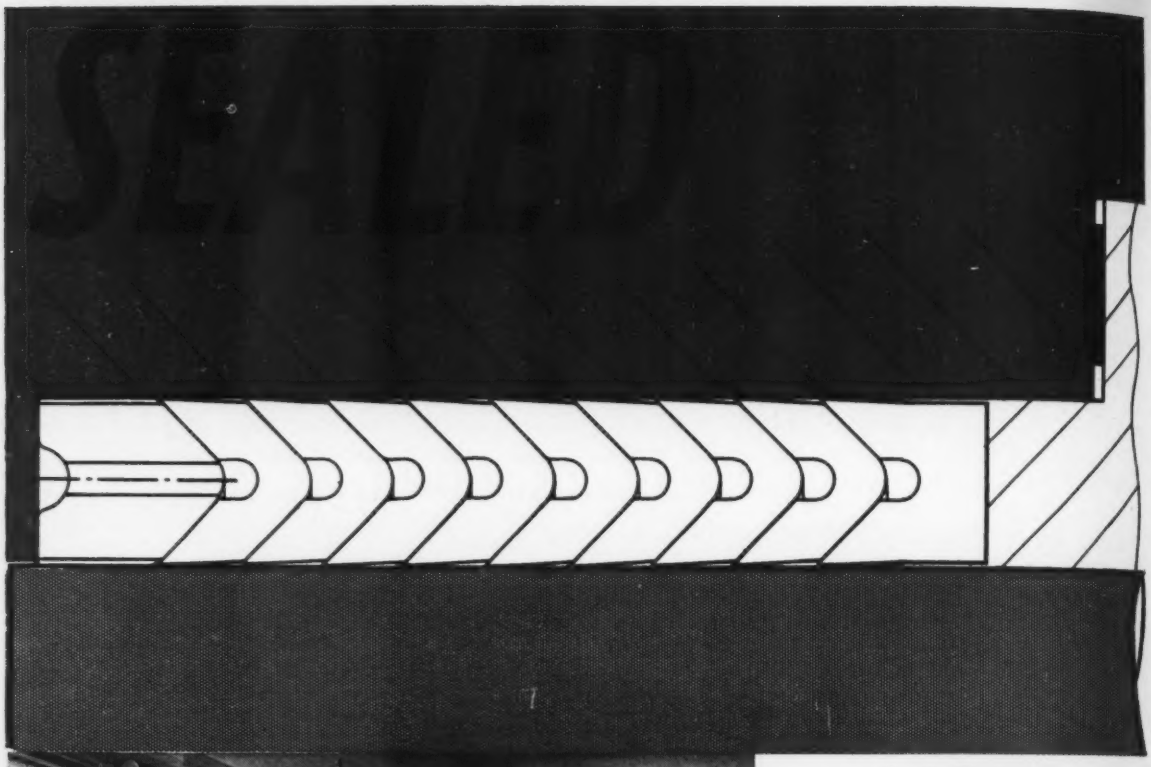

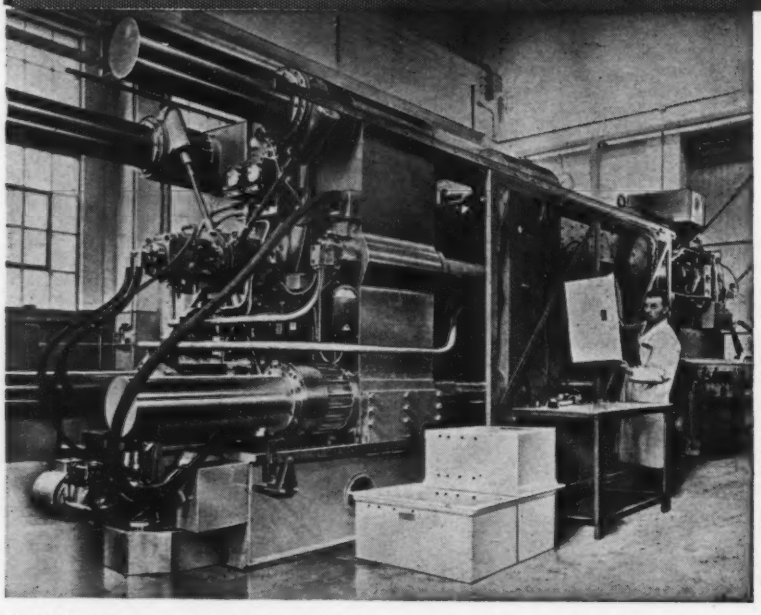

This injection press, by R. H. Windsor Ltd., is the largest designed and built in Britain. It produces thermo-plastic mouldings up to 12lb. in weight. Photo by courtesy of EKCO PLASTICS LIMITED.

LION 'Chevron' packings

The huge horizontal intensifier ram on the Windsor injection press shown opposite—no less than 3ft. in diameter, and operating at a pressure of 2,600 p.s.i.—is effectively sealed by LION "Chevron" packings 36in. i.d. x 38in. o.d. x 5¾in. deep. (See full scale illustration above).

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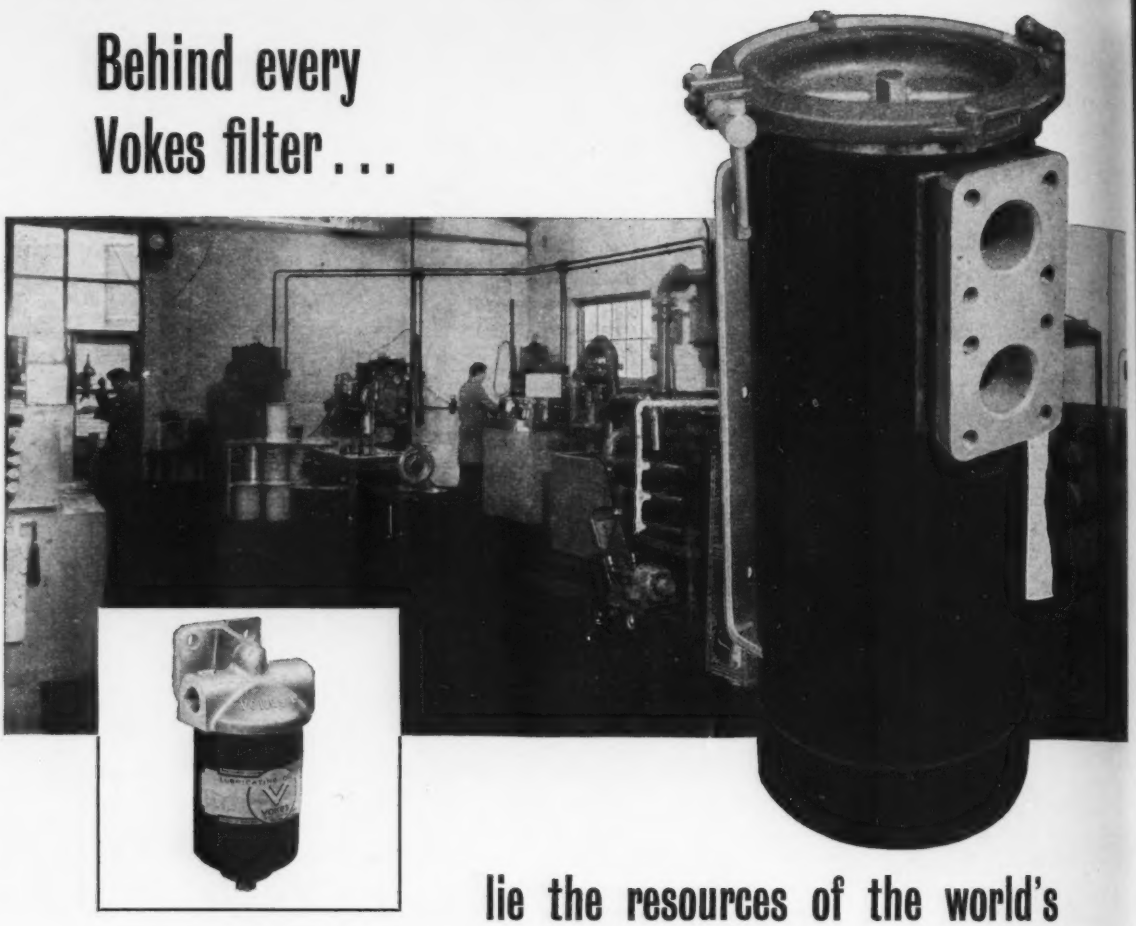

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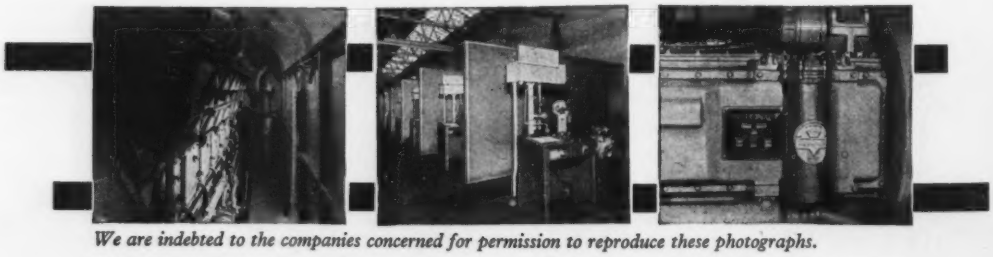
Left is a lube oil filter, incorporating the unique Vokes by-pass device, designed to filter oil carried in external piping. Its outstanding, easily renewed VAF 66 filter cartridge has, compared with other similar size elements, greater sludge holding capacity, considerably improved flow characteristics and longer life. Above is a 'Top Servicing' lube oil filter, with VAF 2 filter element, featuring a single articulated clamp ring which considerably simplifies element renewal. Vokes lubricating oil filters are inexpensive on first cost, simple to install and the most economical in use.



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Vokes 'Top Servicing' filter fitted alongside the Mirrlees engine of a Type 2 loco built for British Railways by Brush Traction Ltd.

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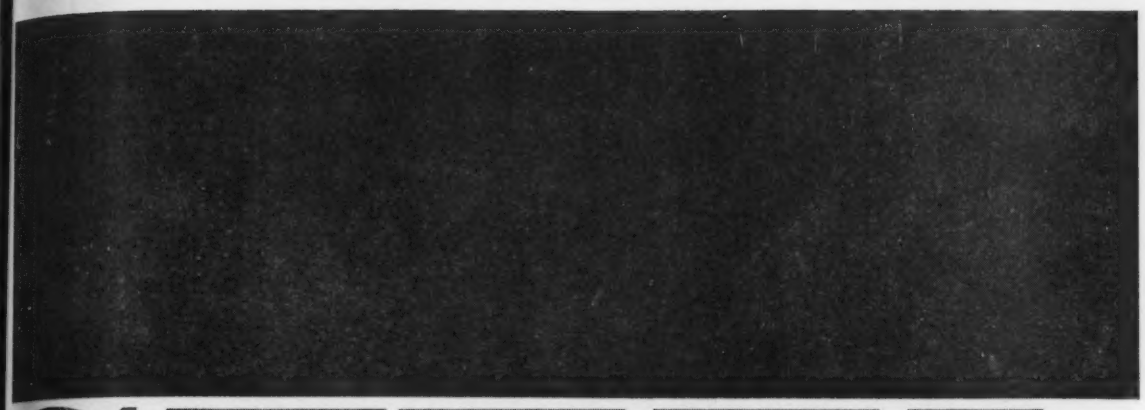

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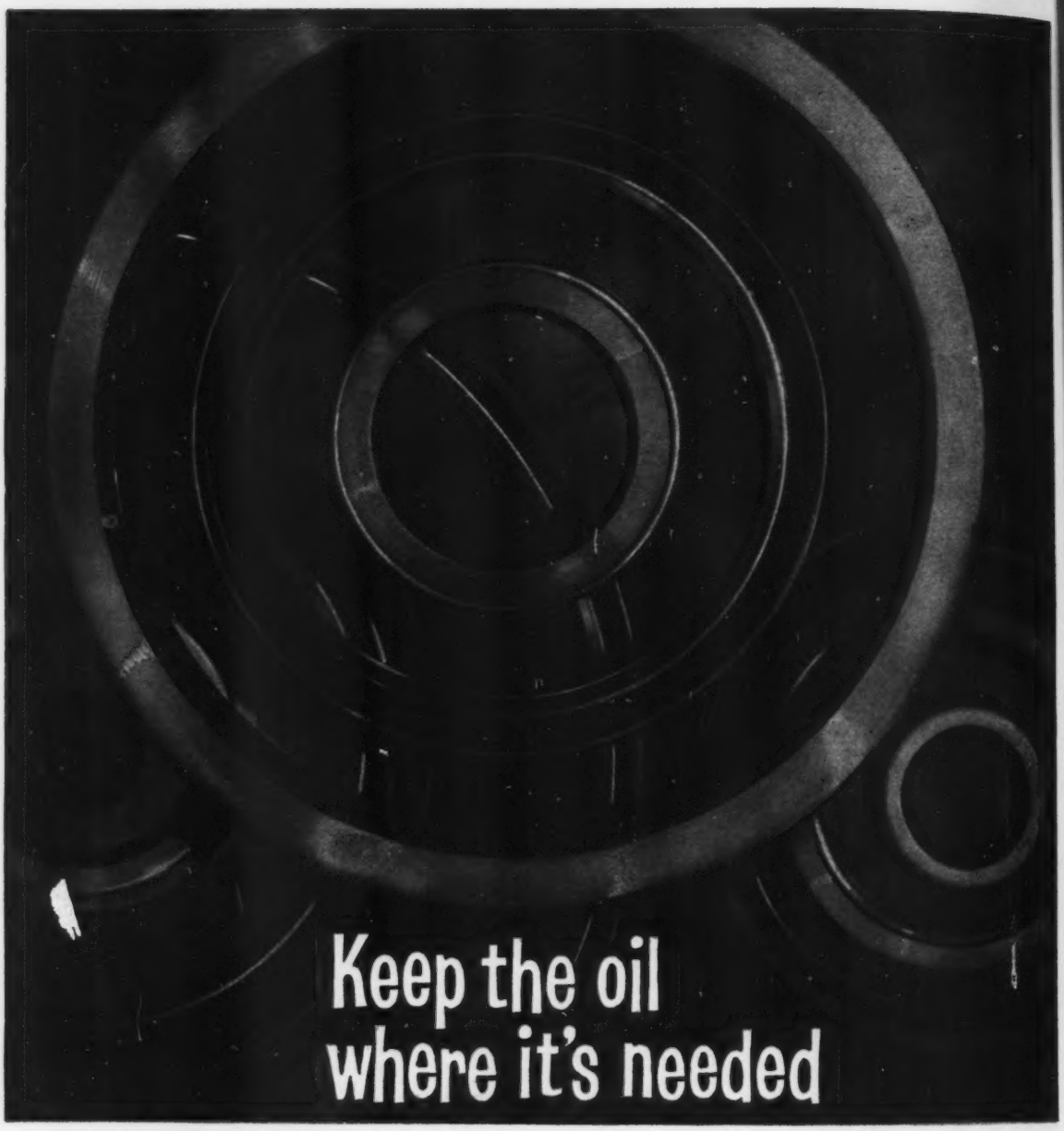

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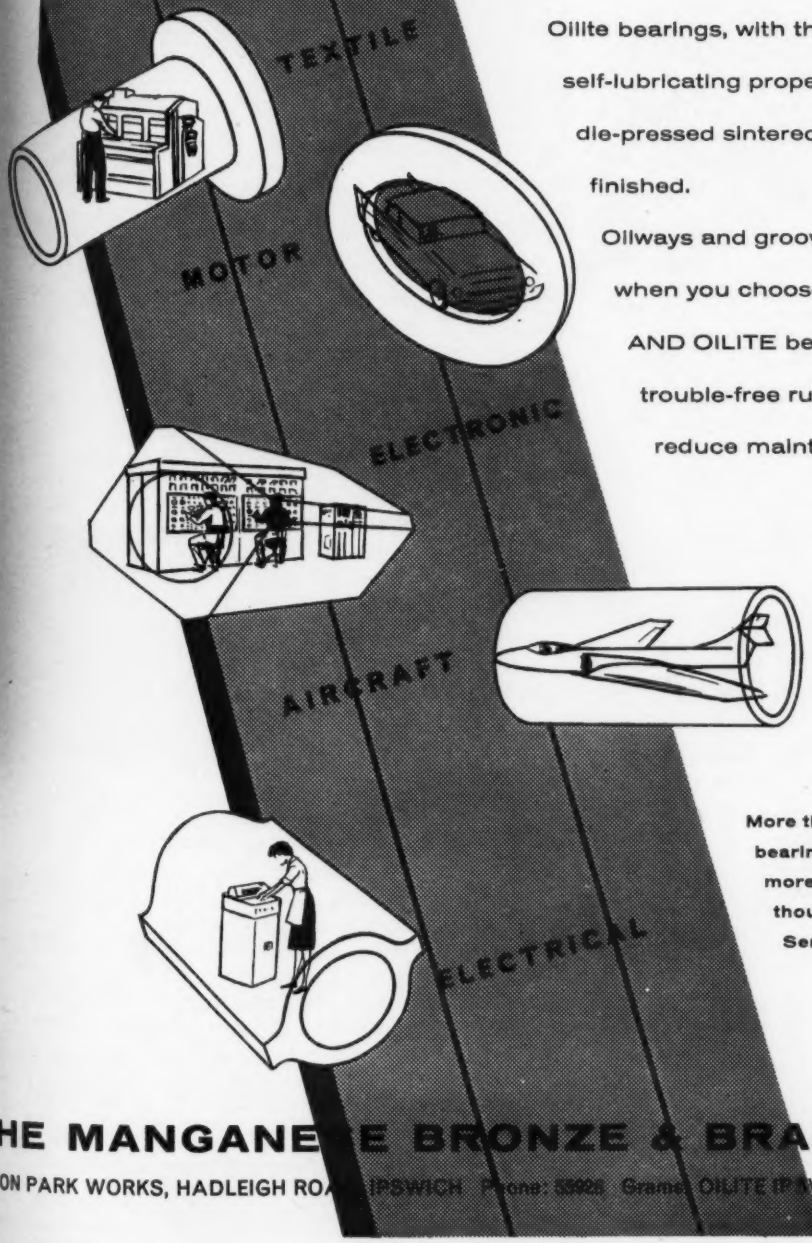

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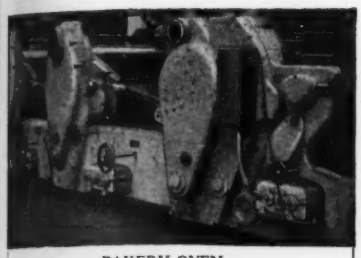

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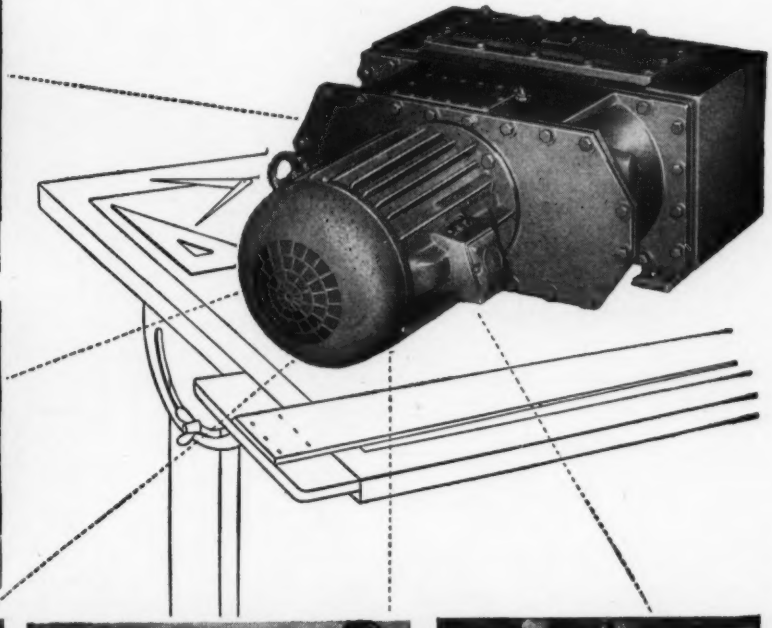

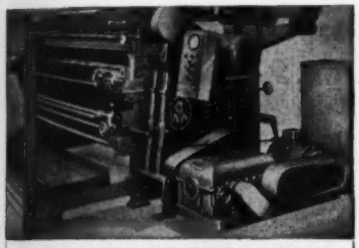

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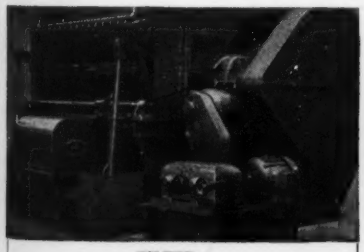

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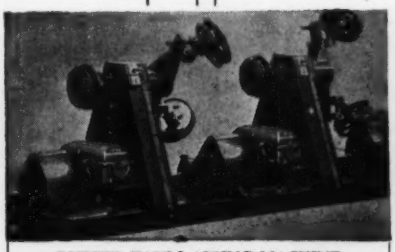

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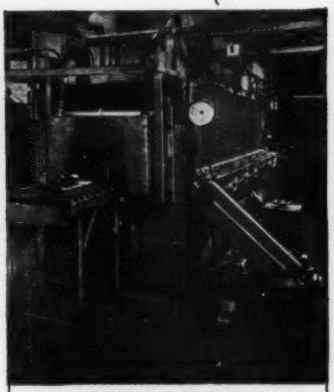

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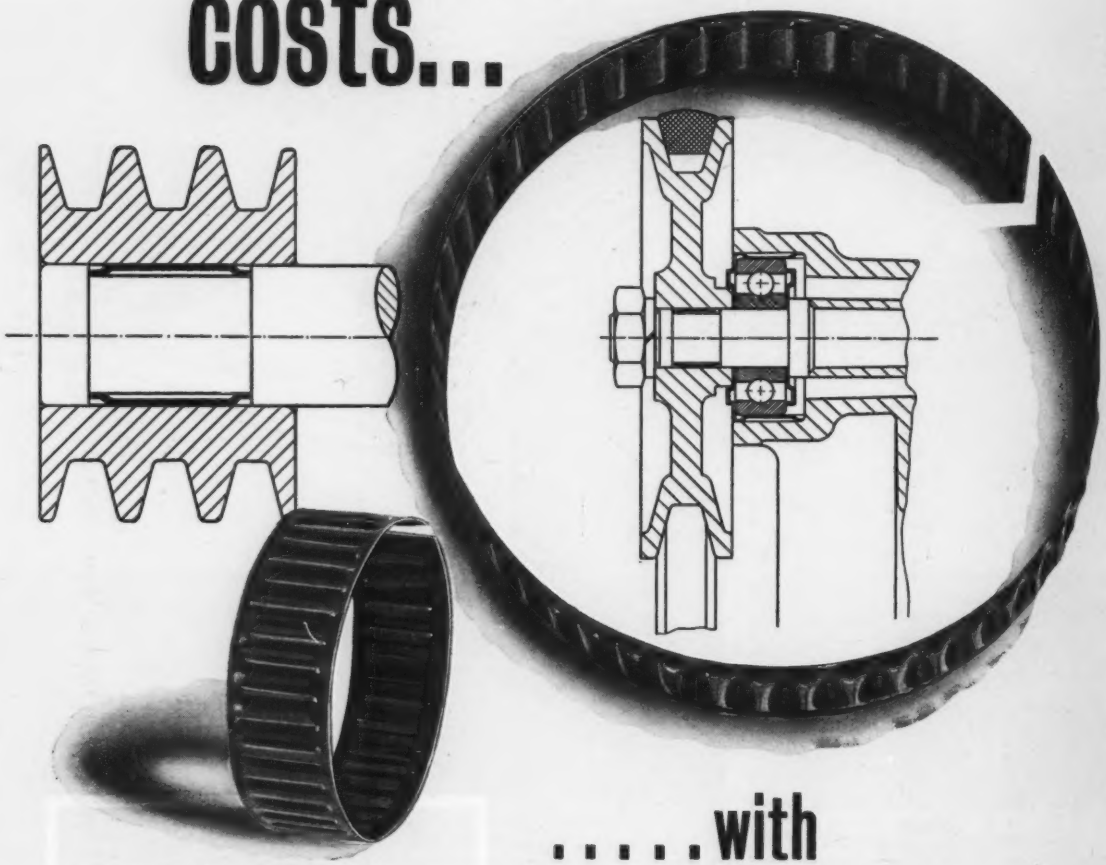

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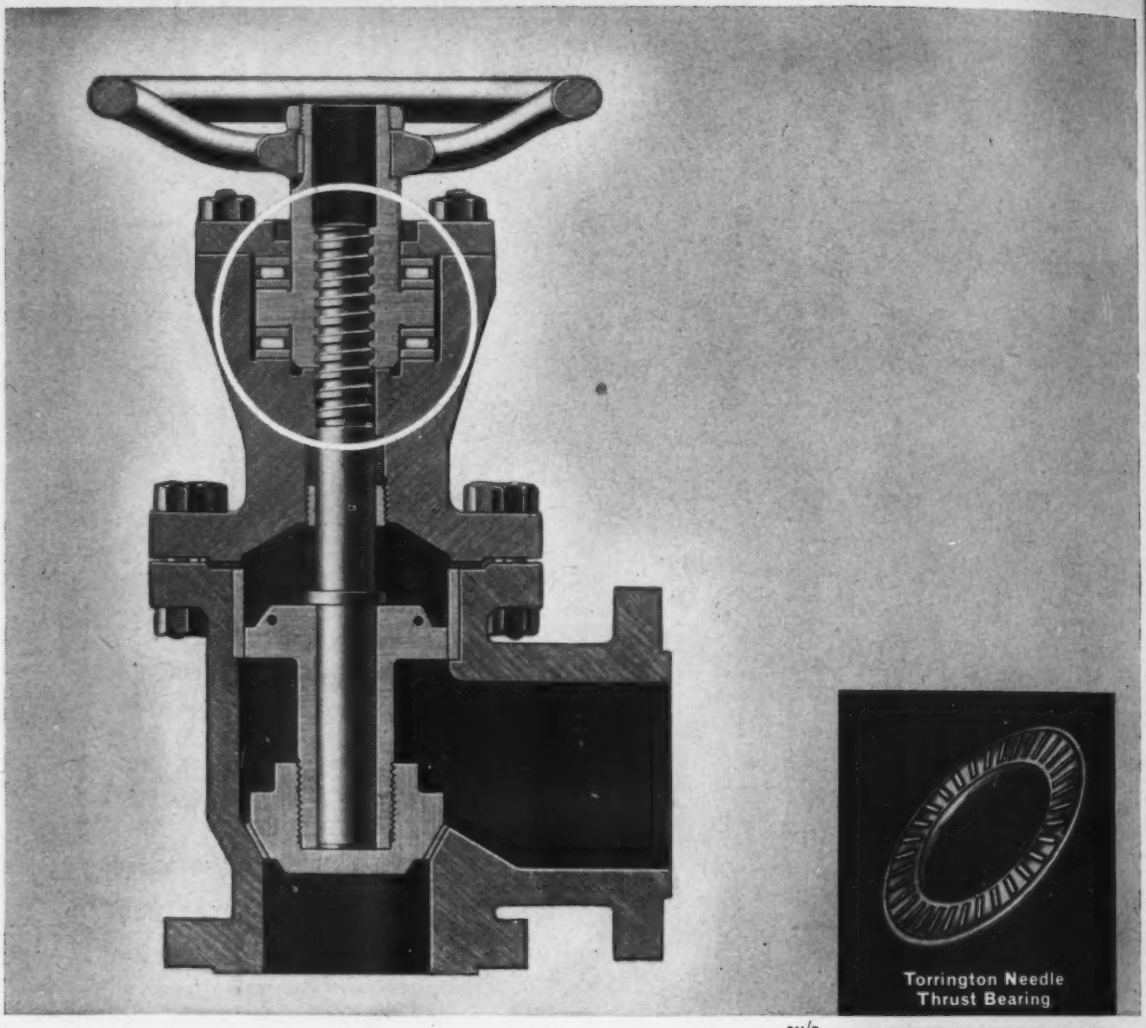

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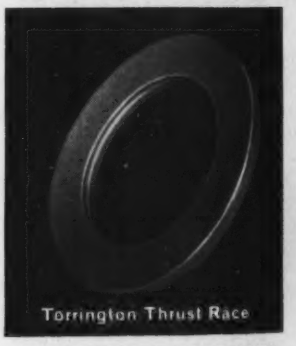

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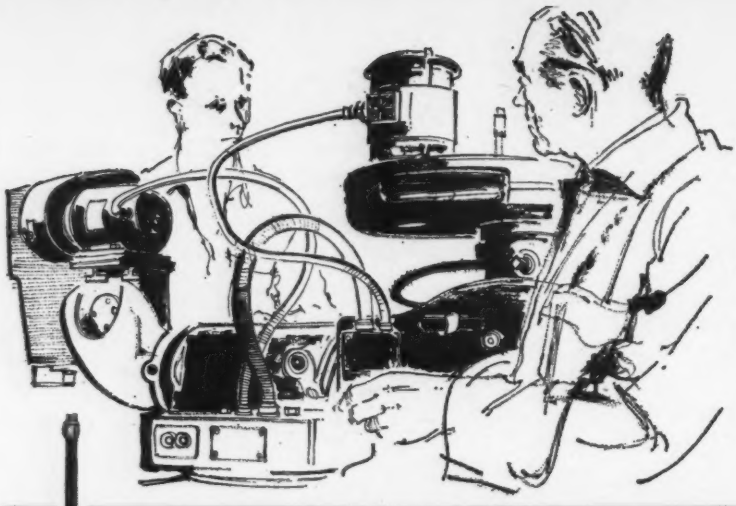

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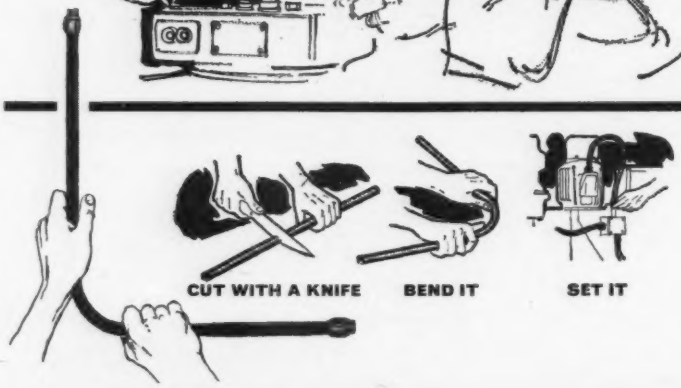

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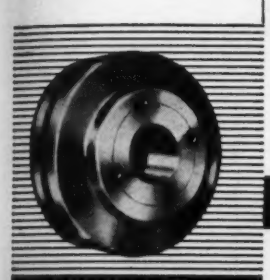

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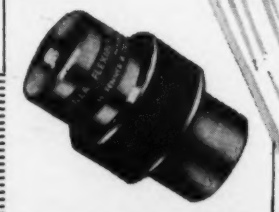

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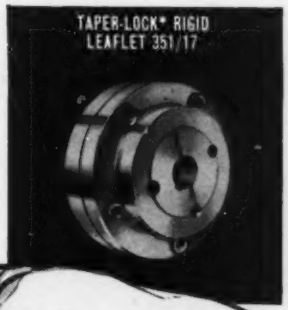

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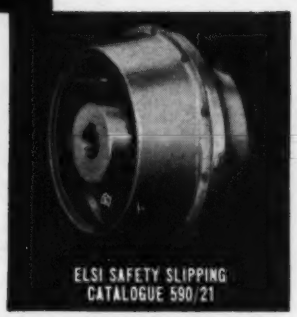

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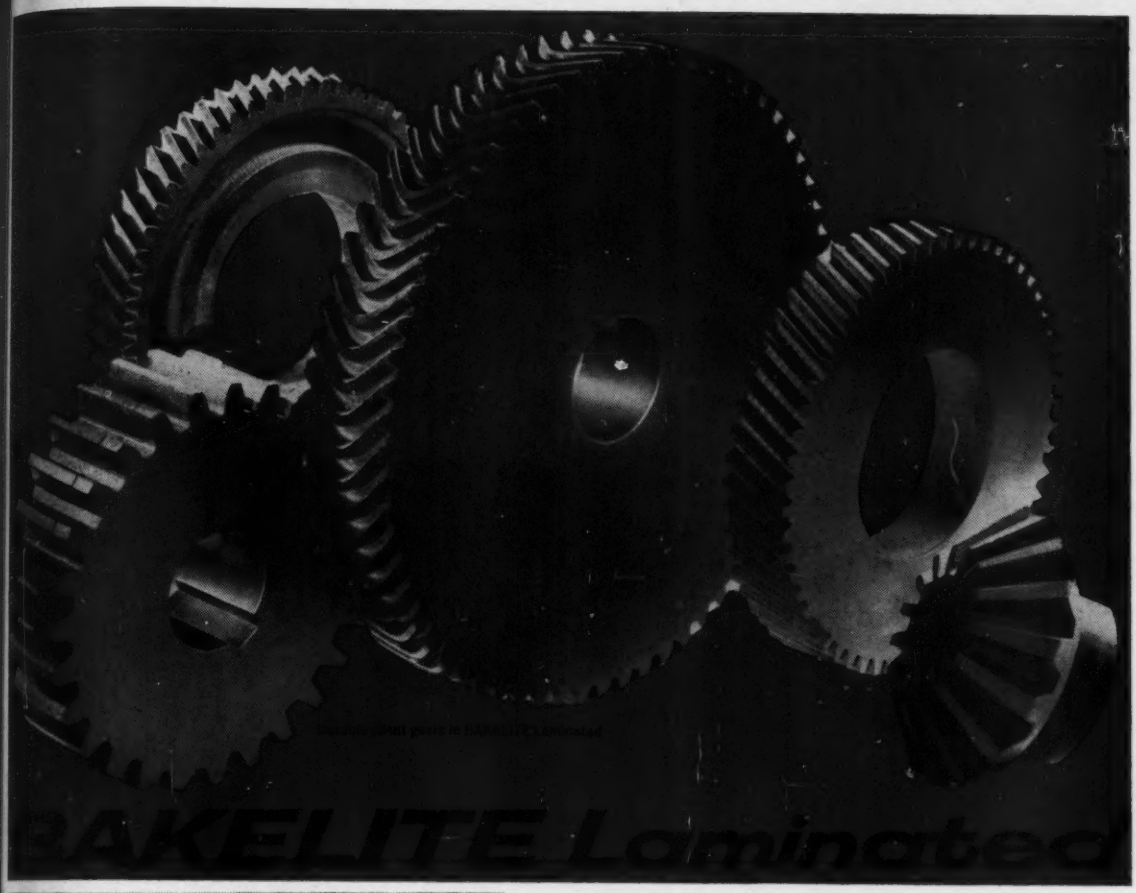

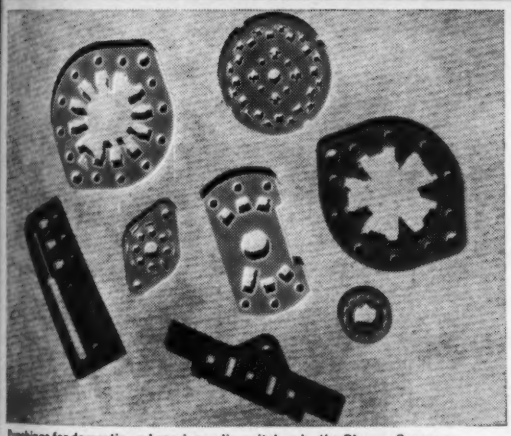

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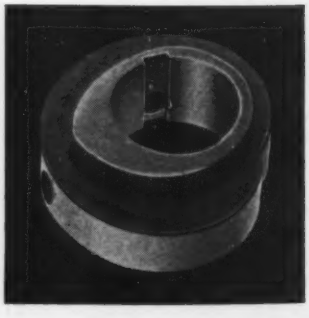

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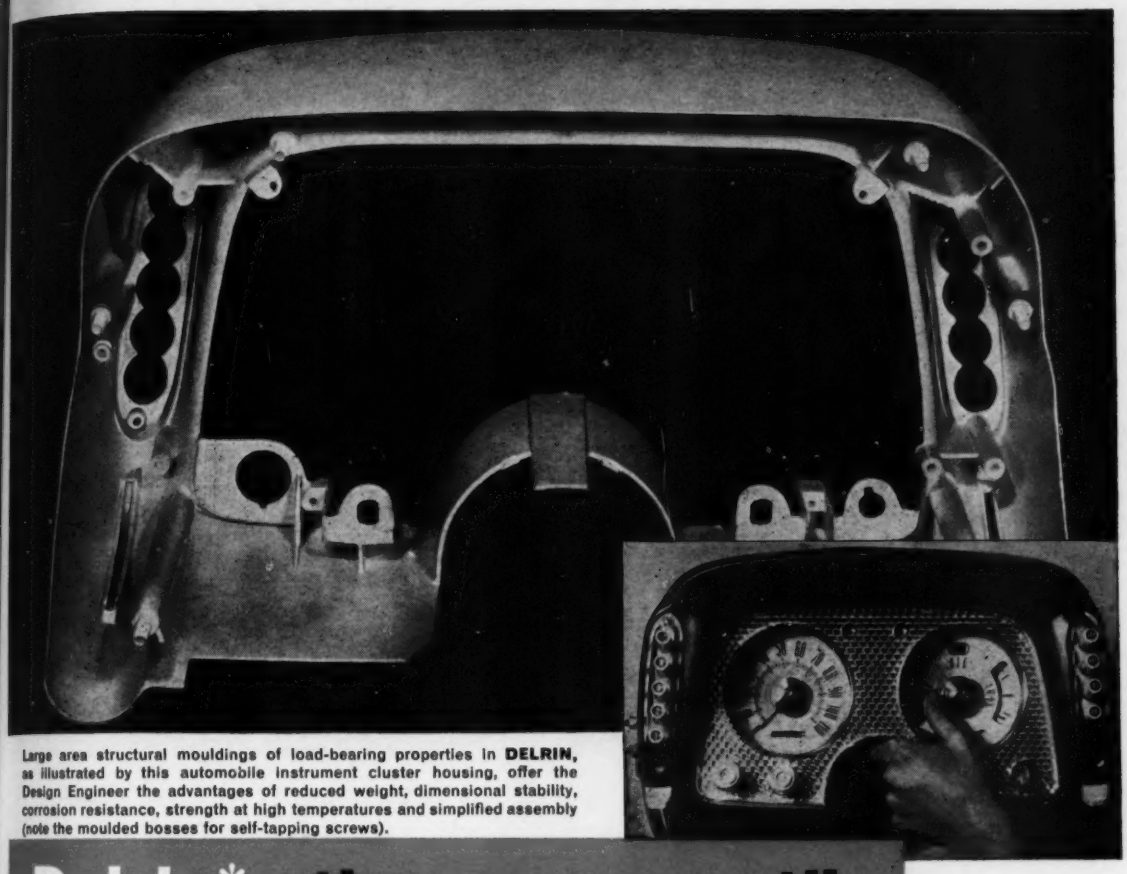

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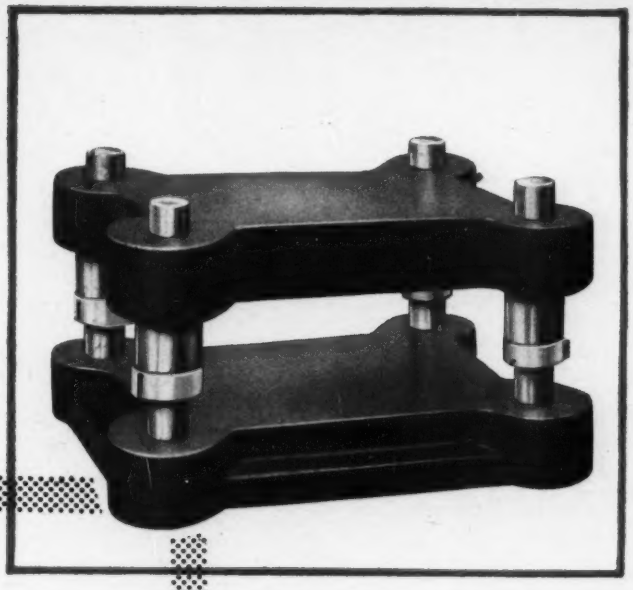

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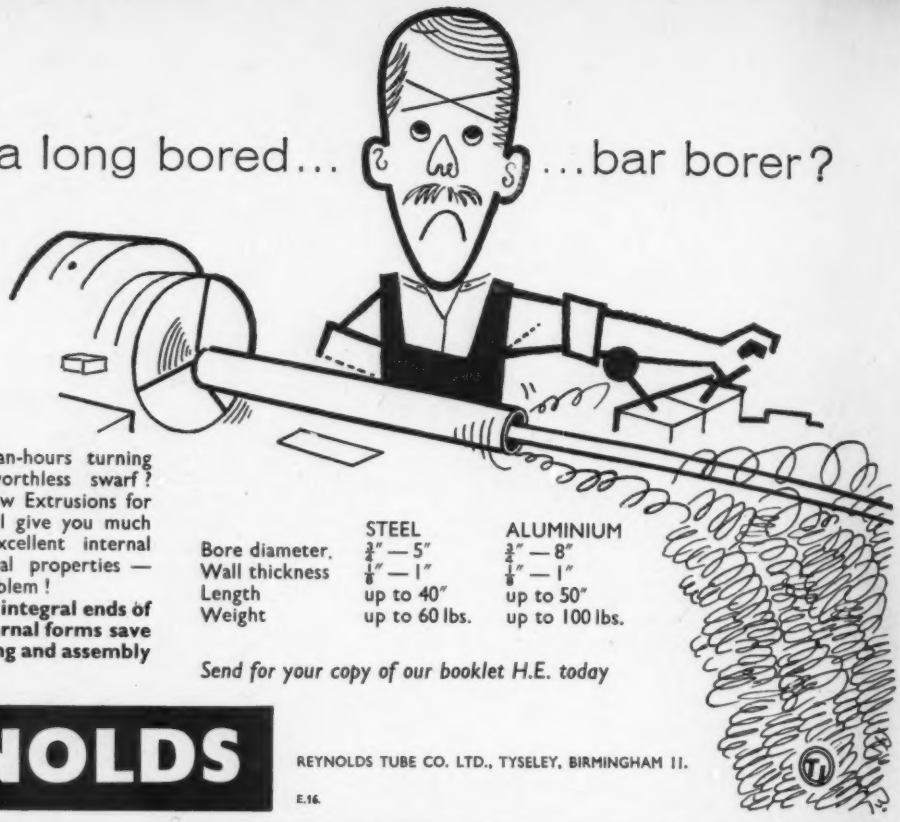

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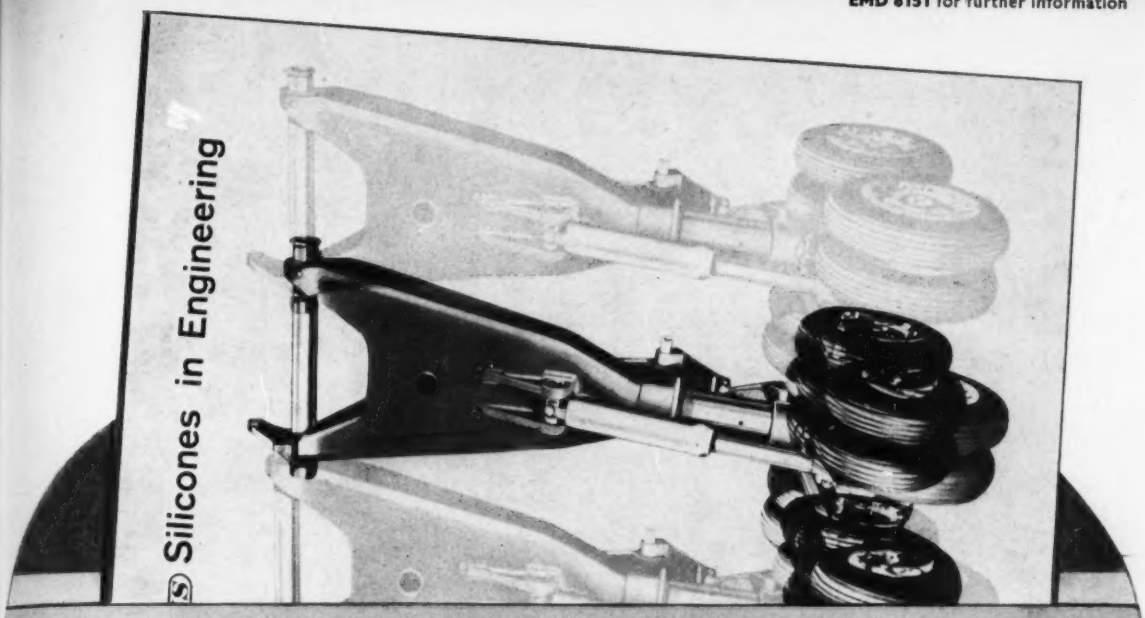

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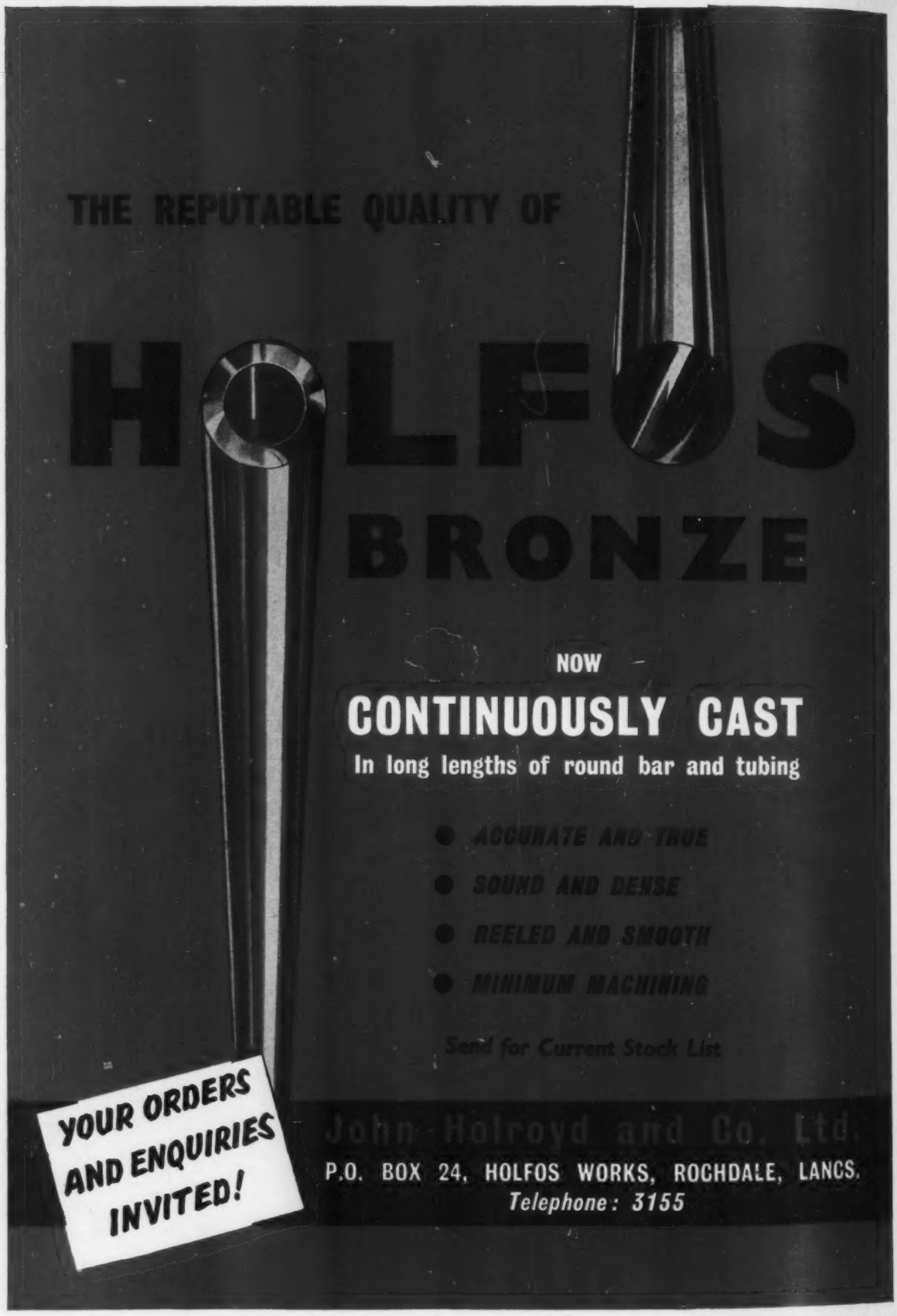
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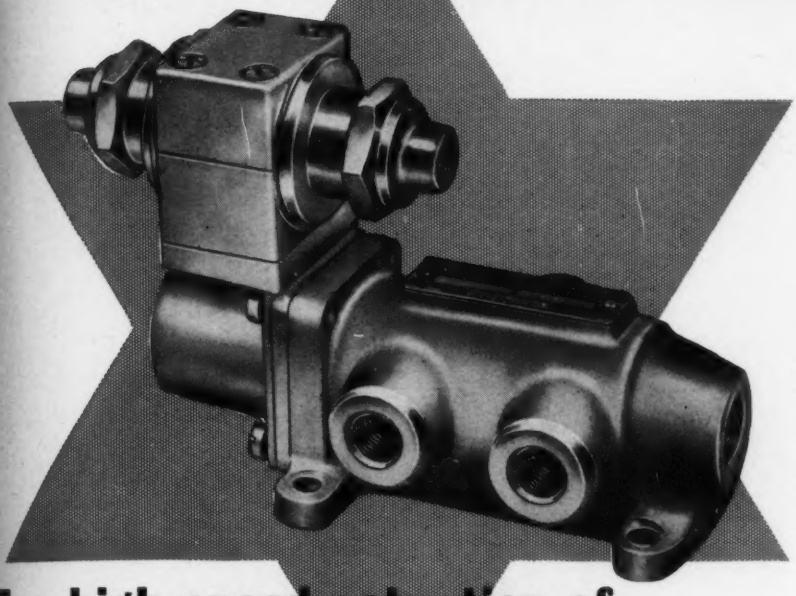

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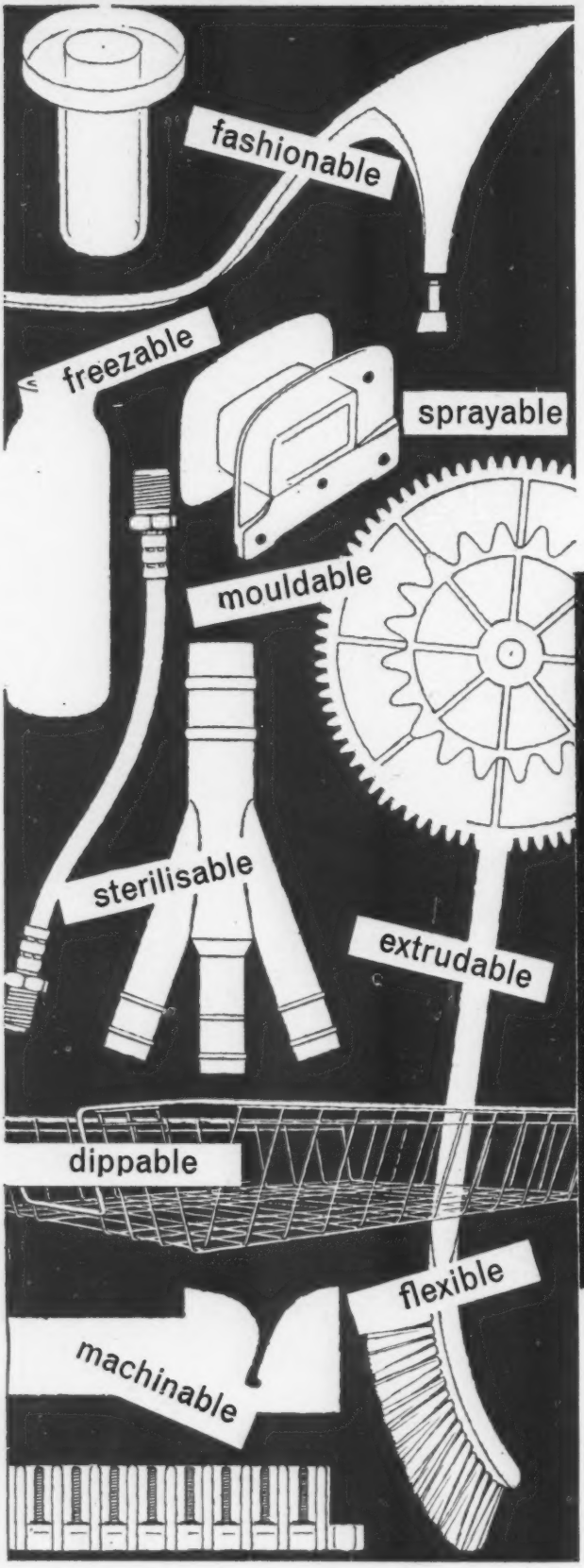

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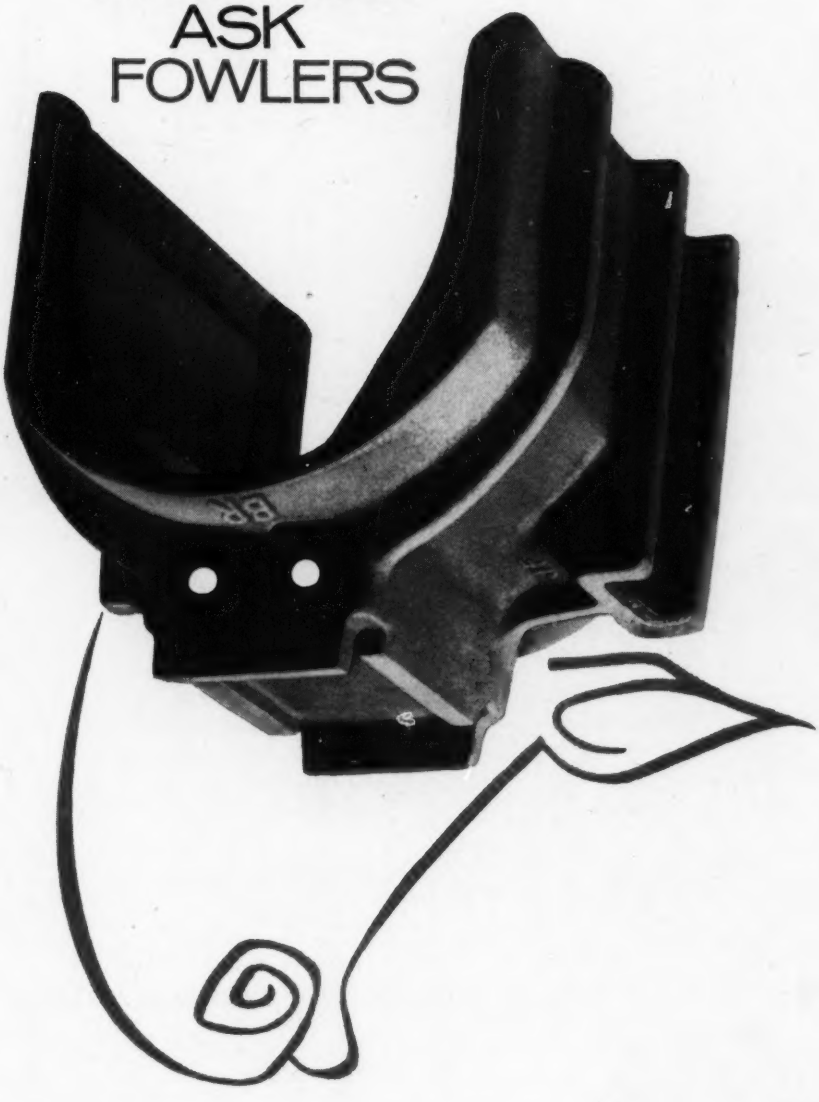

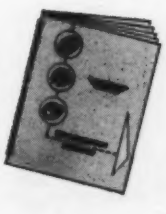

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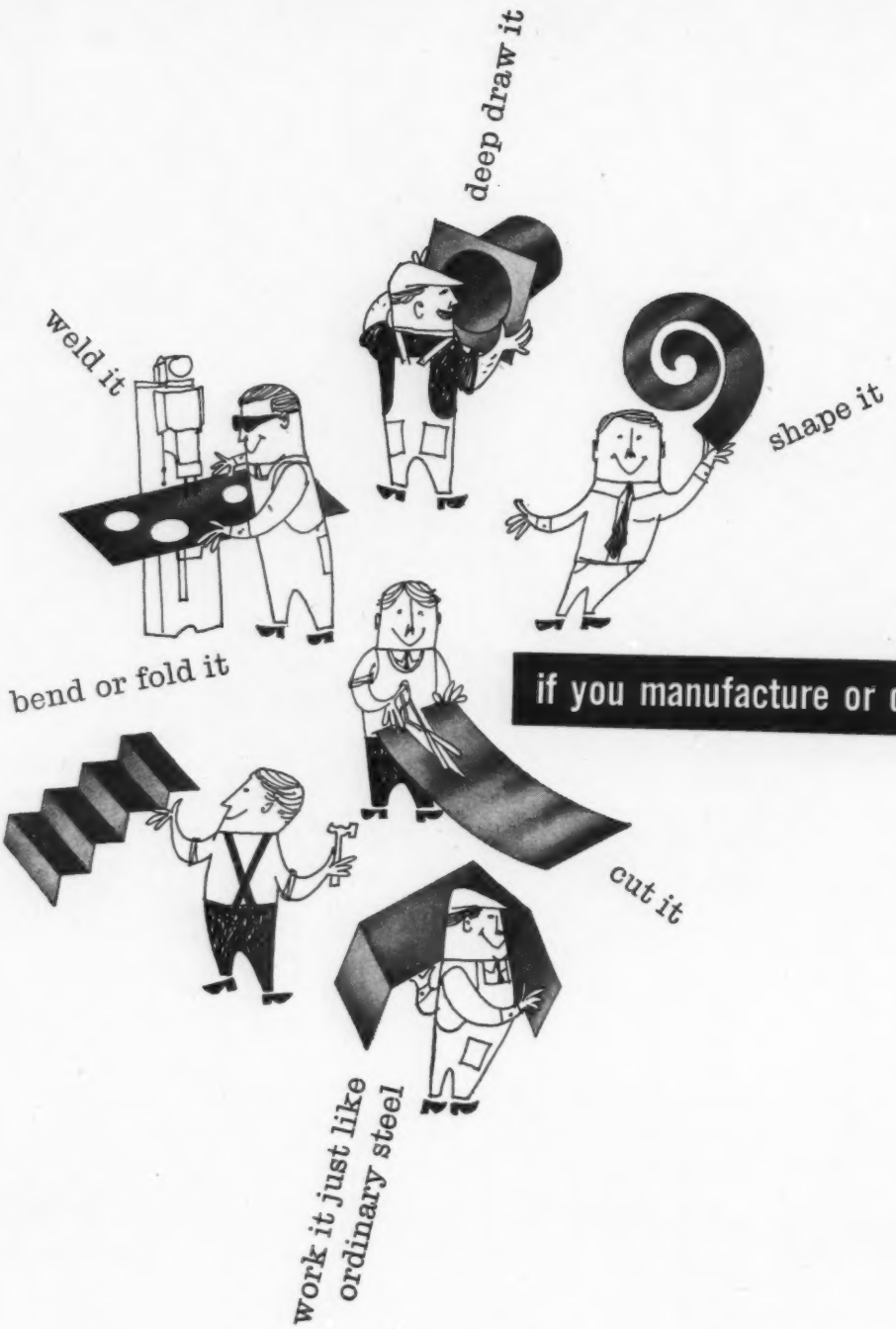
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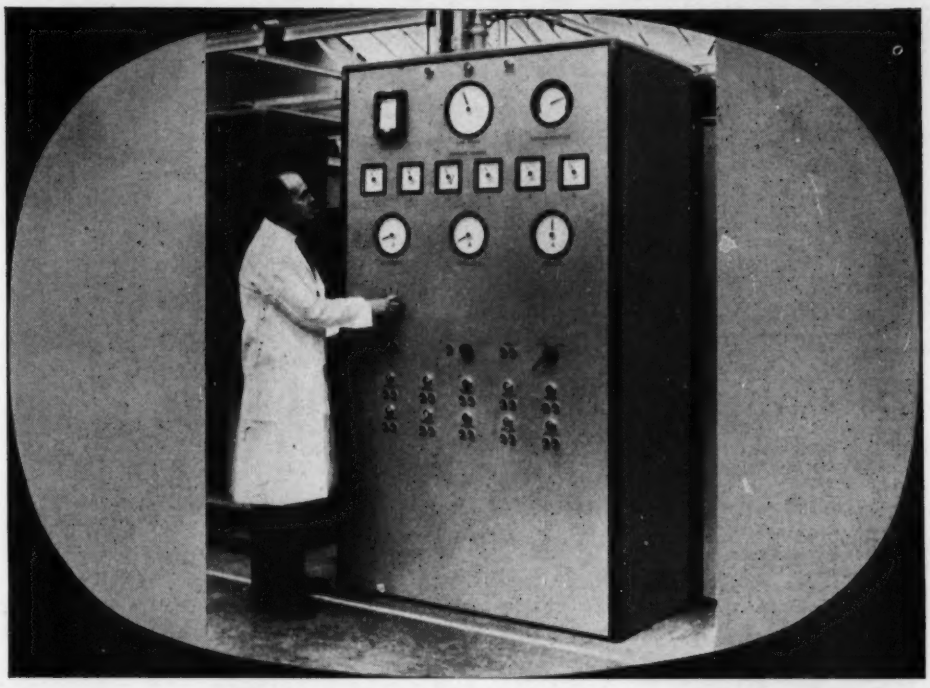

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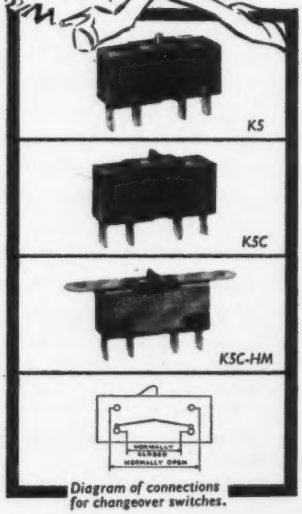

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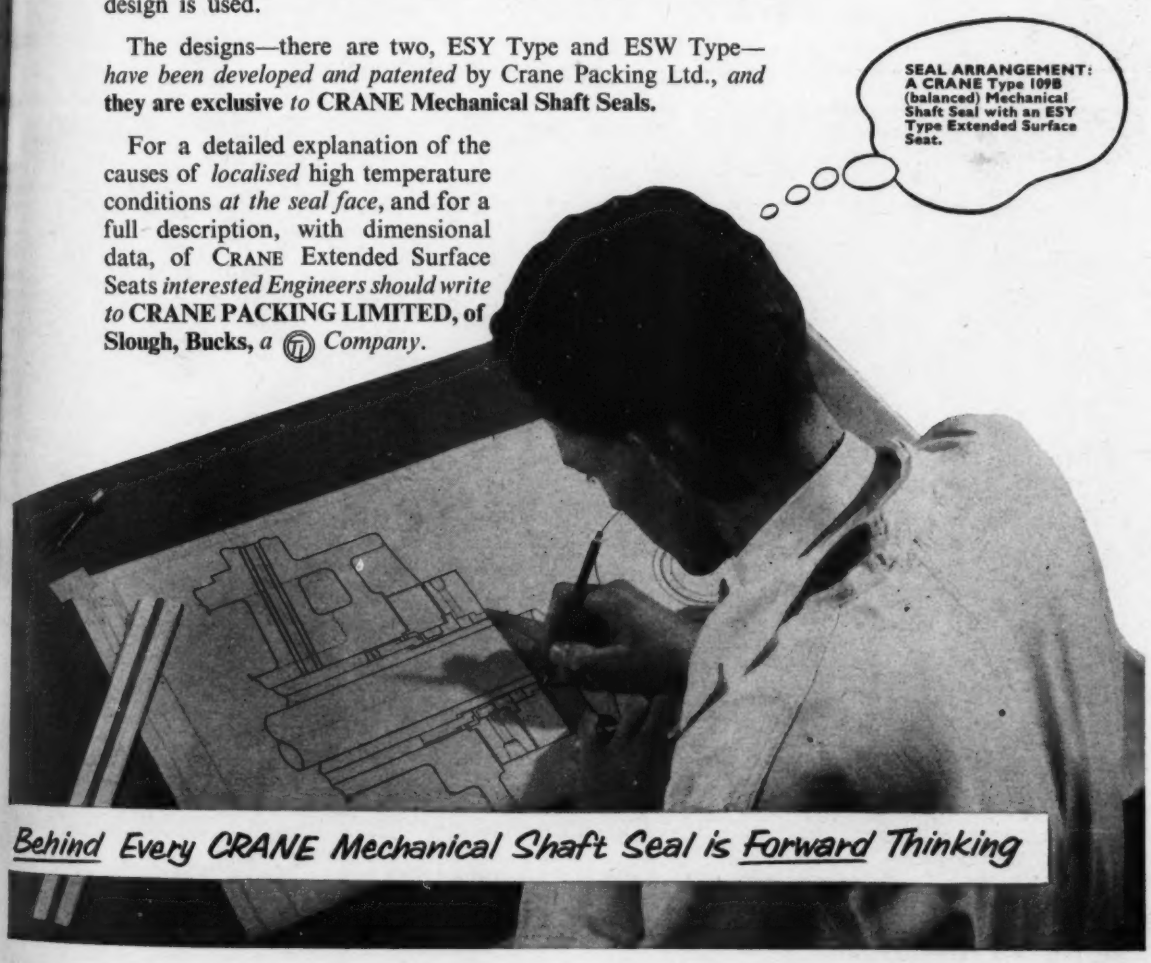

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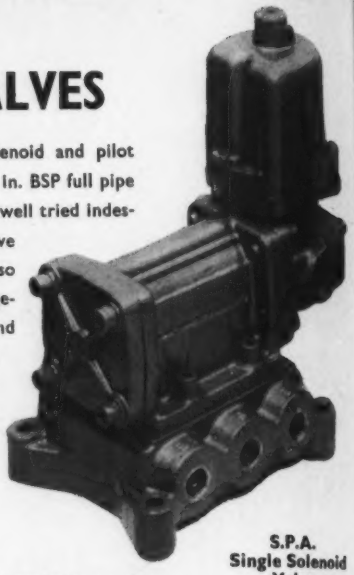

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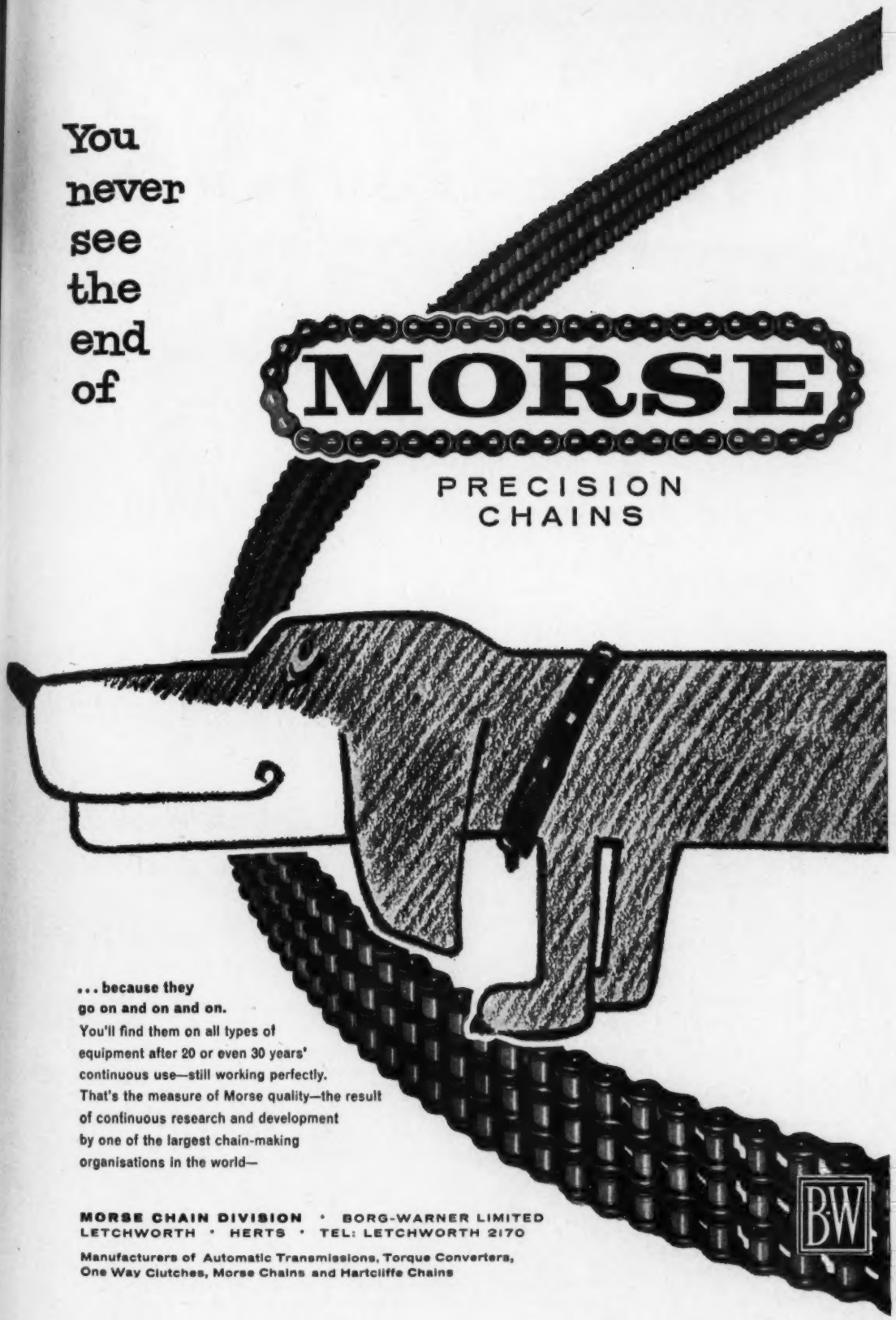

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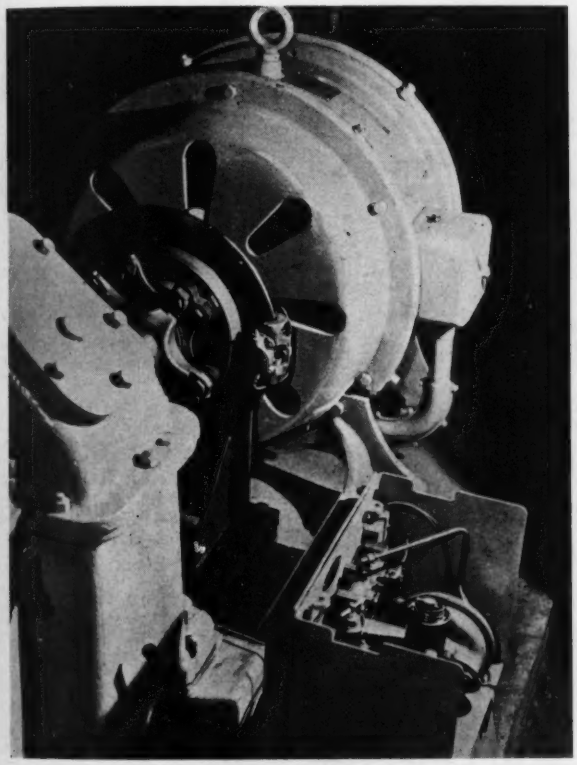

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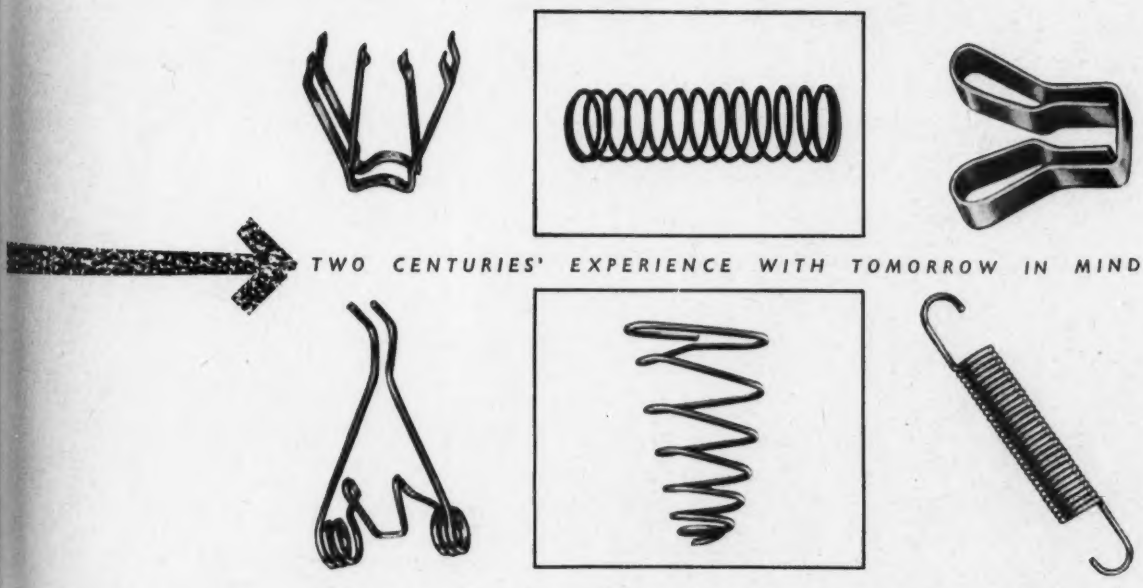

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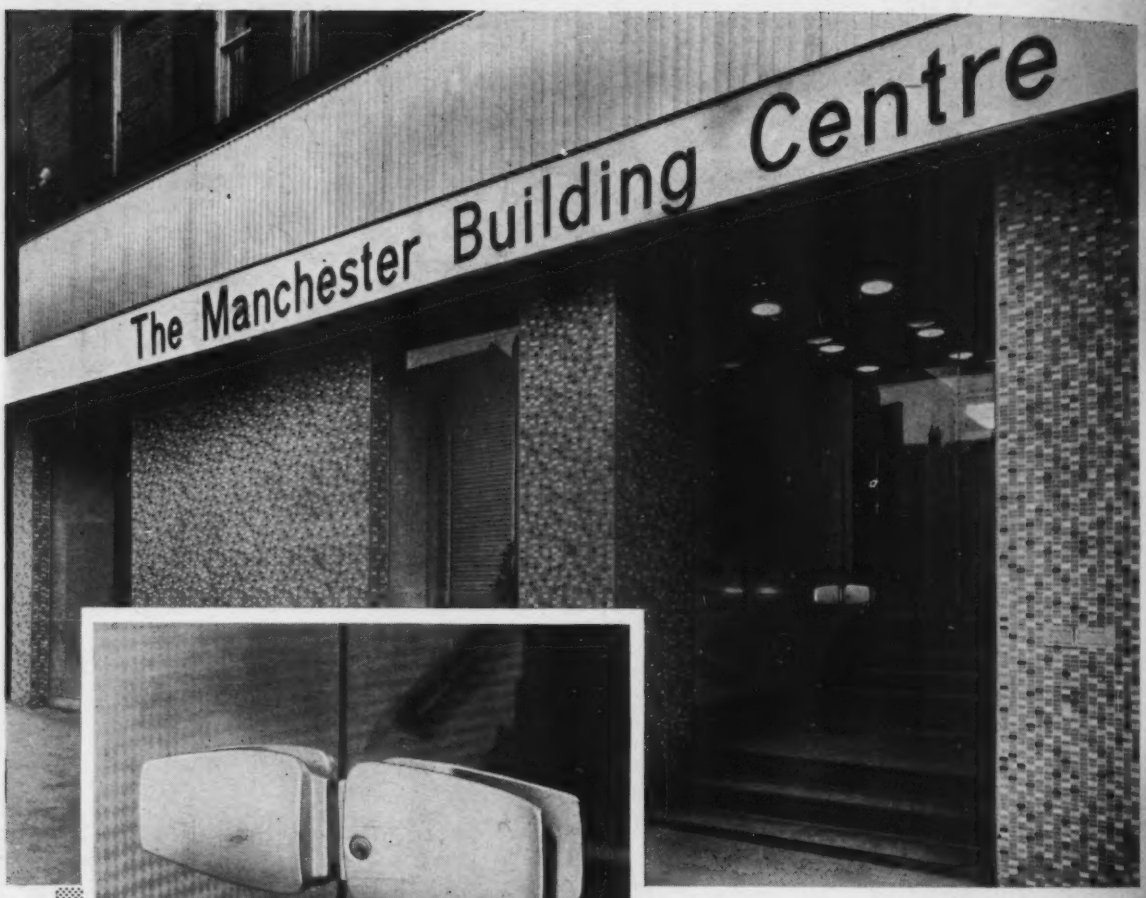

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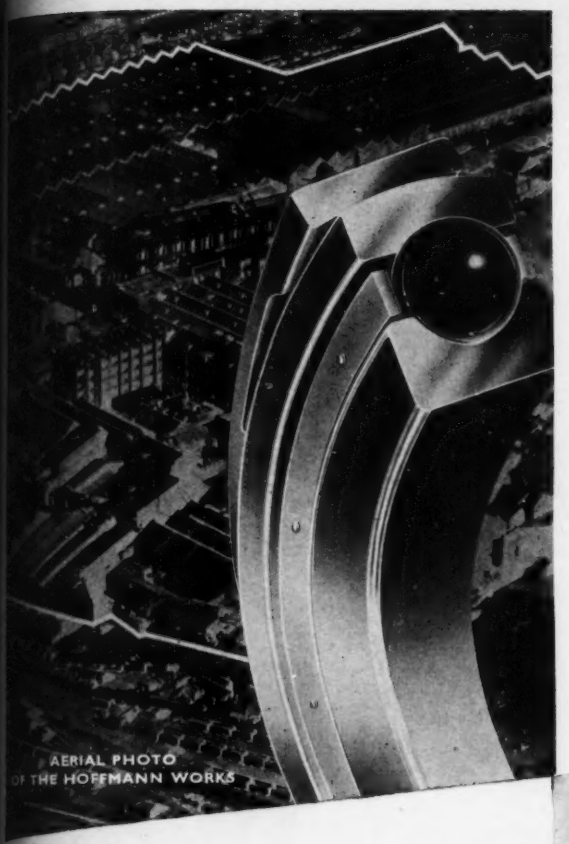

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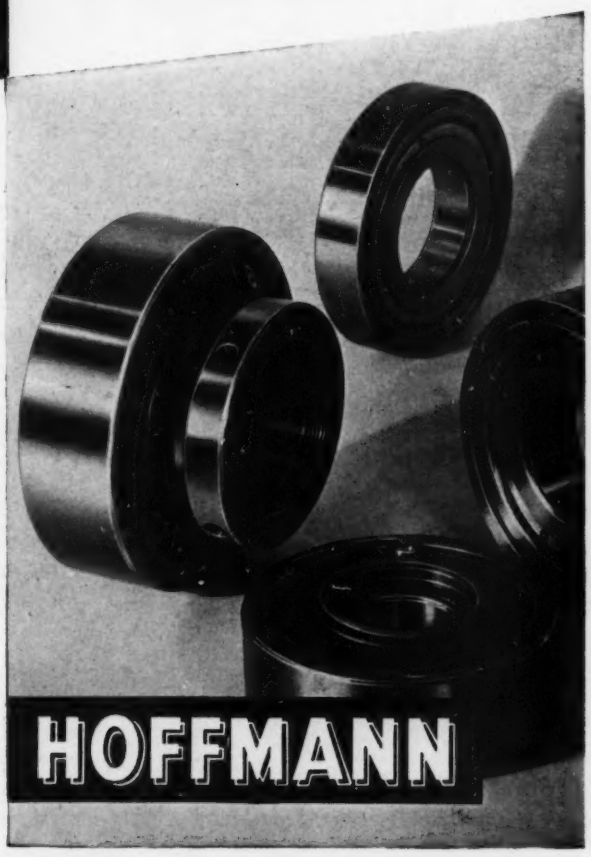

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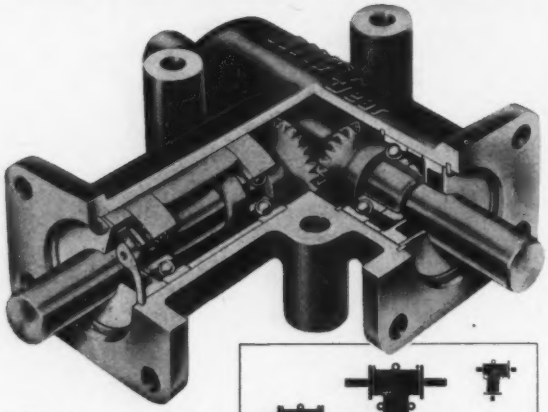

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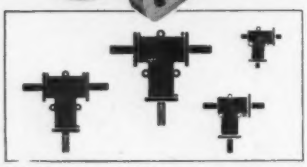

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BASIC MODEL DATA

Model	Type	Gear Ratio	HP	RPM Output Shaft	Allowed O'hung Load (lb.)	Shaft Dia.	Wt., lb.
R-300	2-way	1:1	1/4	1800	25	3/8	·5
R-300-2	2-way	2:1	1/6	1800	25	3/8	·5
R-310	3-way	1:1	1/4	1800	25	3/8	·5
R-310-2	3-way	2:1	1/6	1800	25	3/8	·5
R-320	2-way	1:1	3/4	1800	50	5/8	2·2
R-320-2	2-way	2:1	1/2	1800	50	5/8	2·2
R-330	3-way	1:1	3/4	1800	50	5/8	2·4
R-330-2	3-way	2:1	1/2	1800	50	5/8	2·4
R-333	2-way	1:1	1-3/4	1200	100	3/4	8·7
R-333-2	2-way	2:1	1-3/4	1200	100	3/4	8·7
R-335	3-way	1:1	1-3/4	1200	100	3/4	9·0
R-335-2	3-way	2:1	1-3/4	1200	100	3/4	9·0
R-340	2-way	1:1	3-3/4	1200	150	1	14·5
R-340-2	2-way	2:1	3-3/4	1200	150	1	14·5
R-350	3-way	1:1	3-3/4	1200	150	1	15
R-350-2	3-way	2:1	3-3/4	1200	150	1	15

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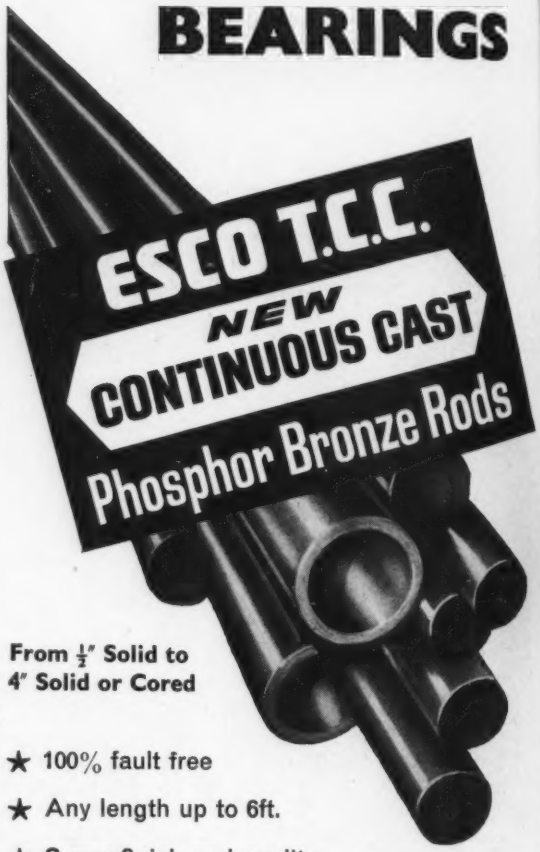

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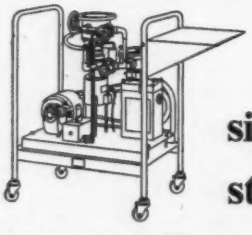

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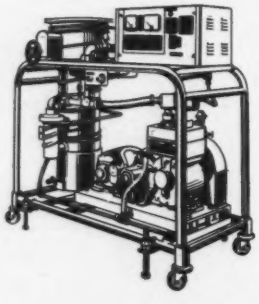

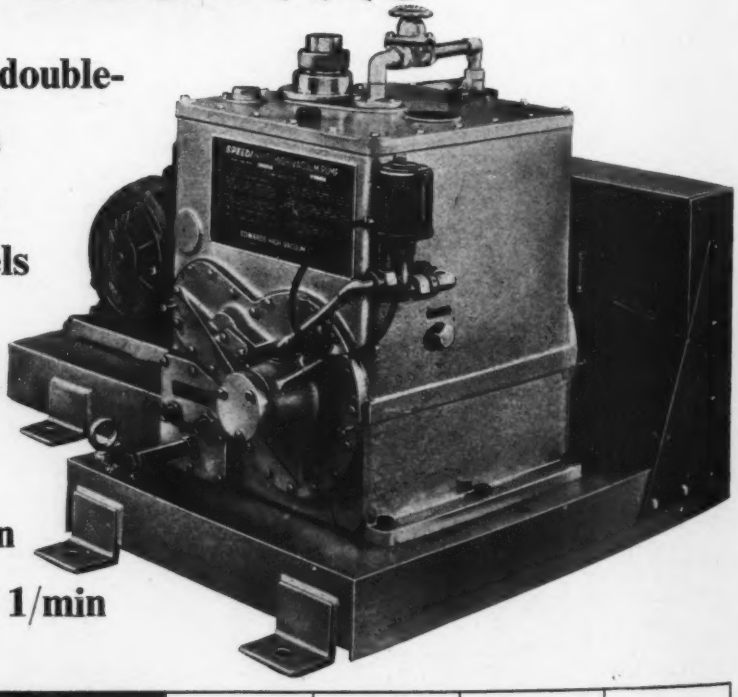

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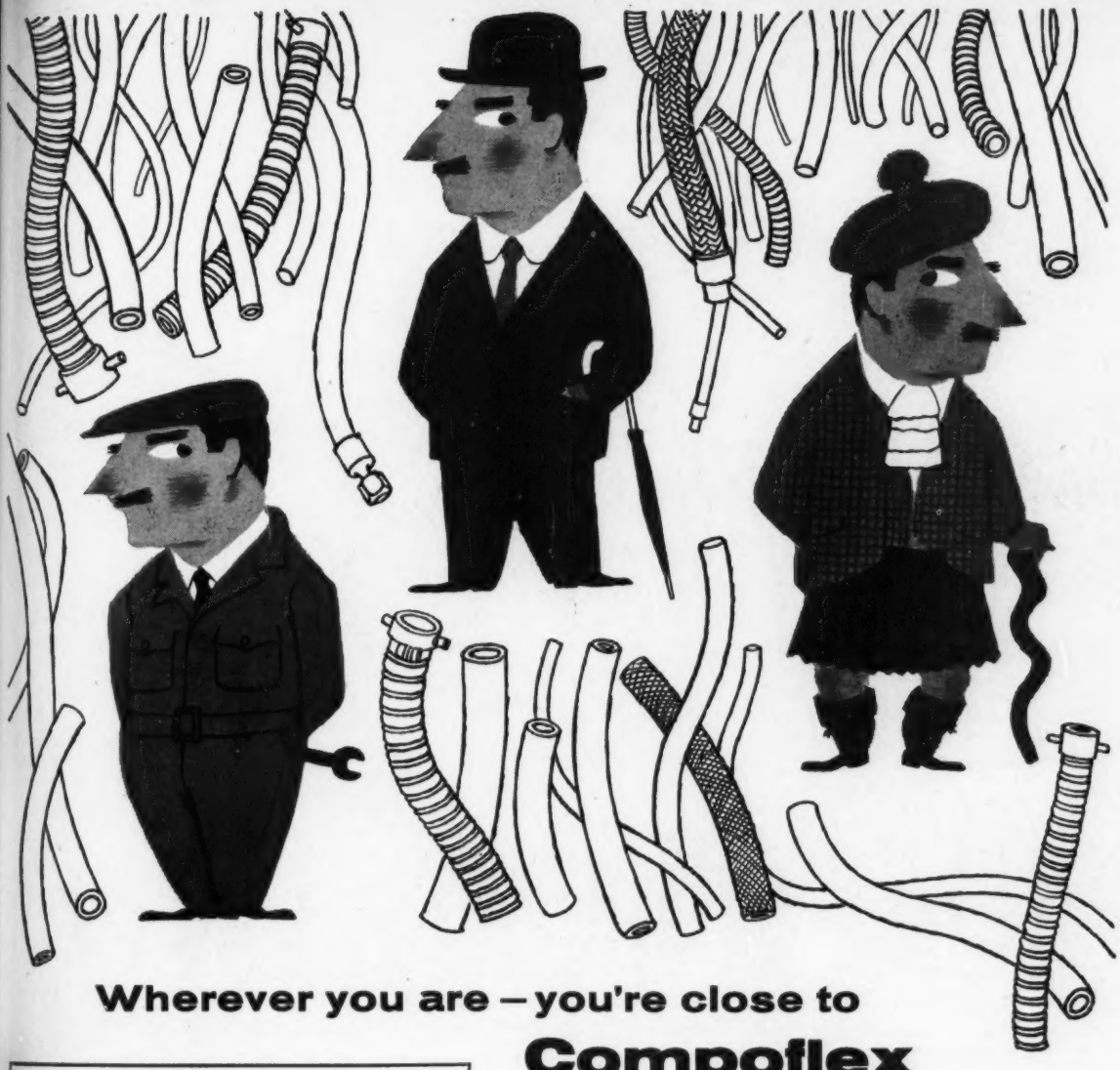

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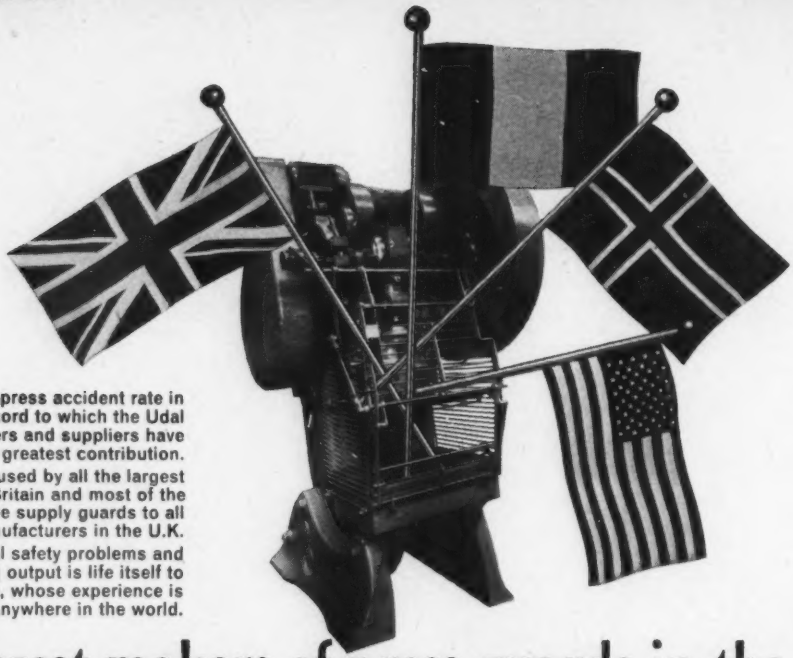

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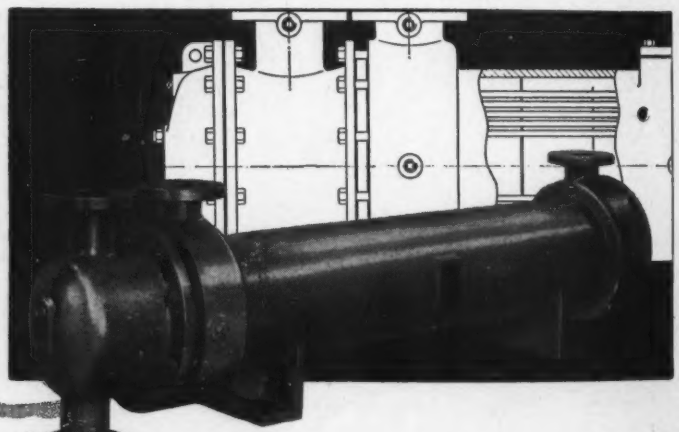

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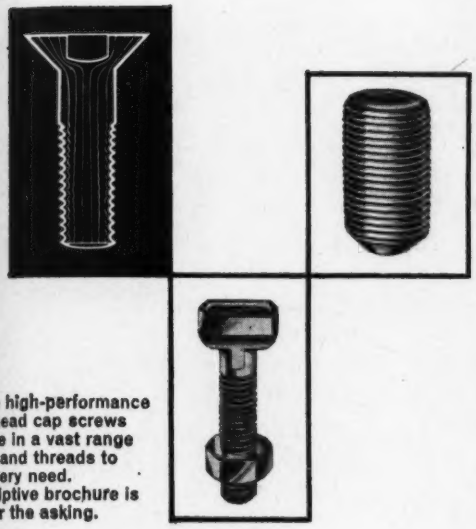

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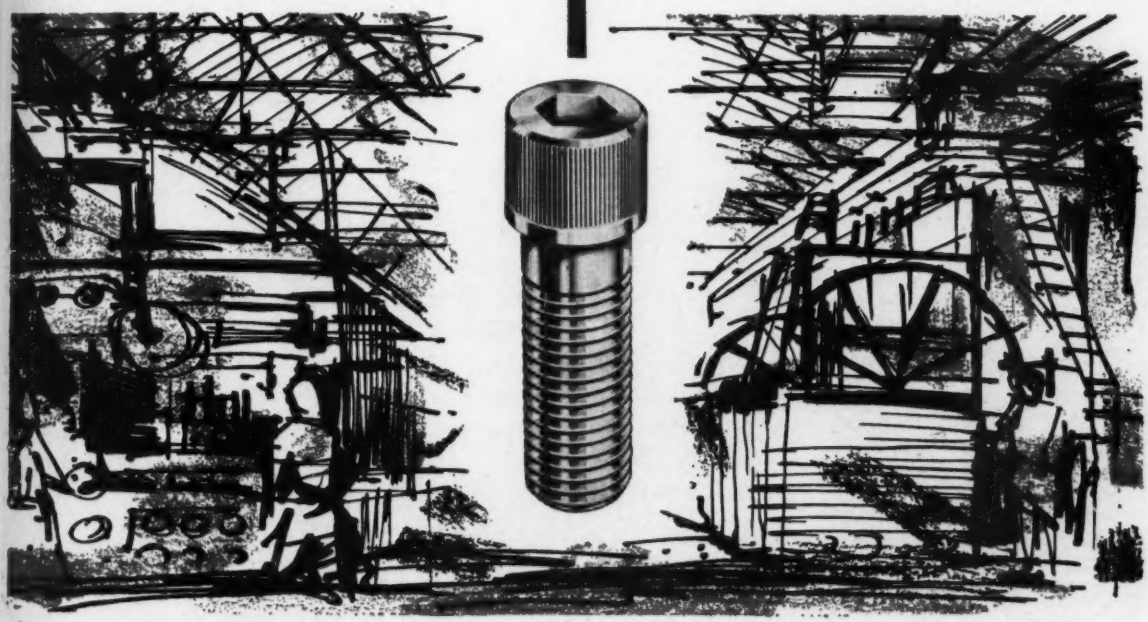

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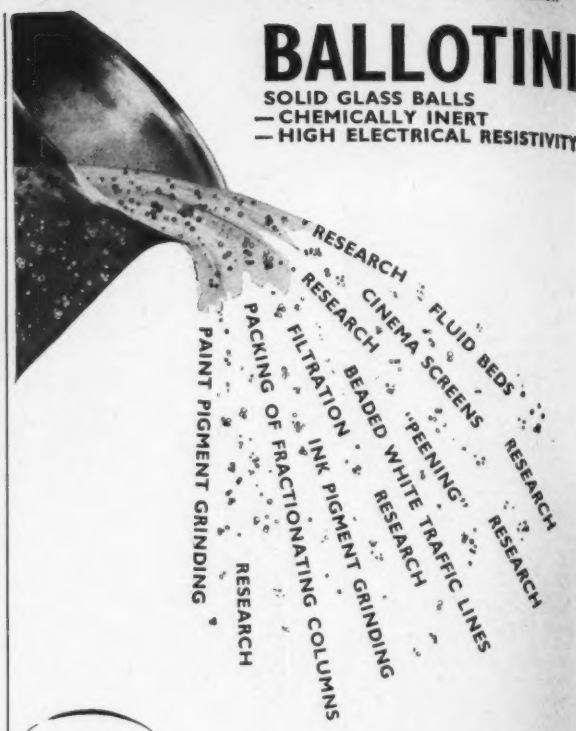

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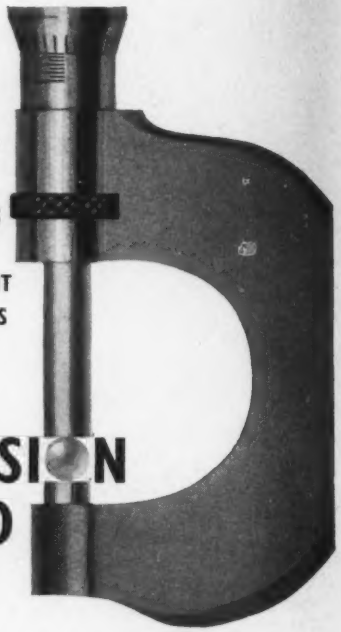

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3% CHROMIUM MOLYBDENUM NITRIDING STEEL

Type of Steel	Typical Core Strength 1⅛" dia. bar tons/sq. in.	Diamond Pyramid Hardness after Nitriding
% C., 1¼% Cr.Al.Mo.	80	"
4% C., " "	60	"
·3% C., " "	50	"
0·2% C., " "	40	850/950
	90	
0·4% C., 3% Cr.Mo.V.		800/850
	60	"
0·3% C., 3% Cr.Mo.	50	
0·2% C., " "		

These steels have been evolved to make the very best use of the Nitriding process of surface hardening by treatment of parts in an Ammonia atmosphere at about 500°C and subsequent cooling at room temperature.

The Firth Brown series consists of some seven principal steels covering a range of surface hardnesses and core tensile strengths which will be found to suit almost every application.

Very clear printed data on this range of steels is available upon request.

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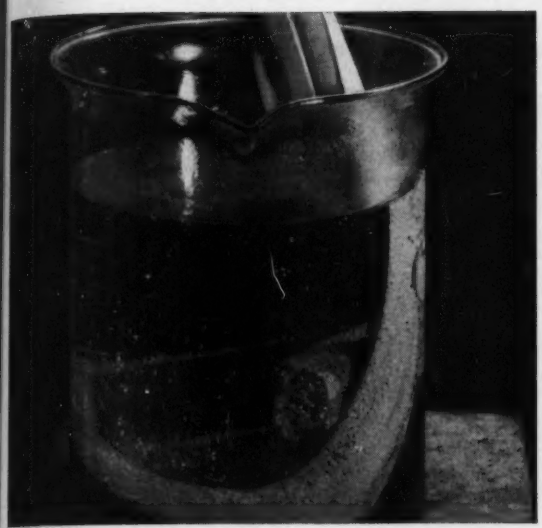
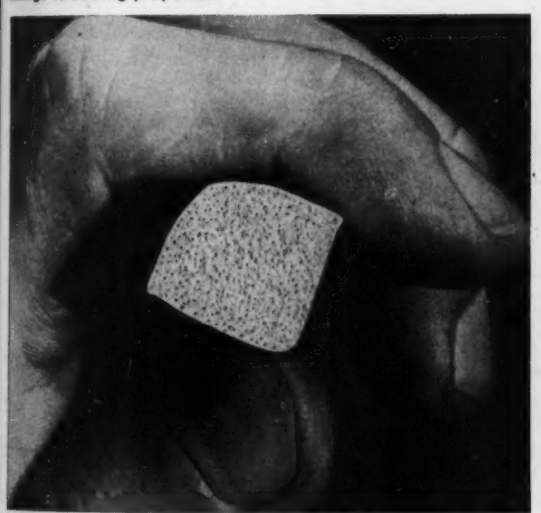


Acceptance tests on closed cell Du Pont neoprene were run for 100 hours in water at 212°F., food fats and detergents at 180°F. Results showed less than 10% swell, low water absorption, no damage to sealing properties.

Gasketing material of closed cell Du Pont neoprene is helping to solve some of the major problems in appliance sealing. This gasketing material has excellent resistance to ozone, abrasion and natural ageing. Made of a non-absorbent body with a thin tough neoprene outer skin, this sealing material performs well under the most severe conditions. Manufacturers' acceptance tests show that it can take hot water, detergents, cooking oils and food chemicals without harm. If you design or manufacture an appliance or assembly involving a compressible seal, you will want more details.

Post coupon for your copy of booklet 'Extruded Closed Cell neoprene Sponge.'



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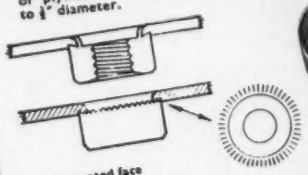

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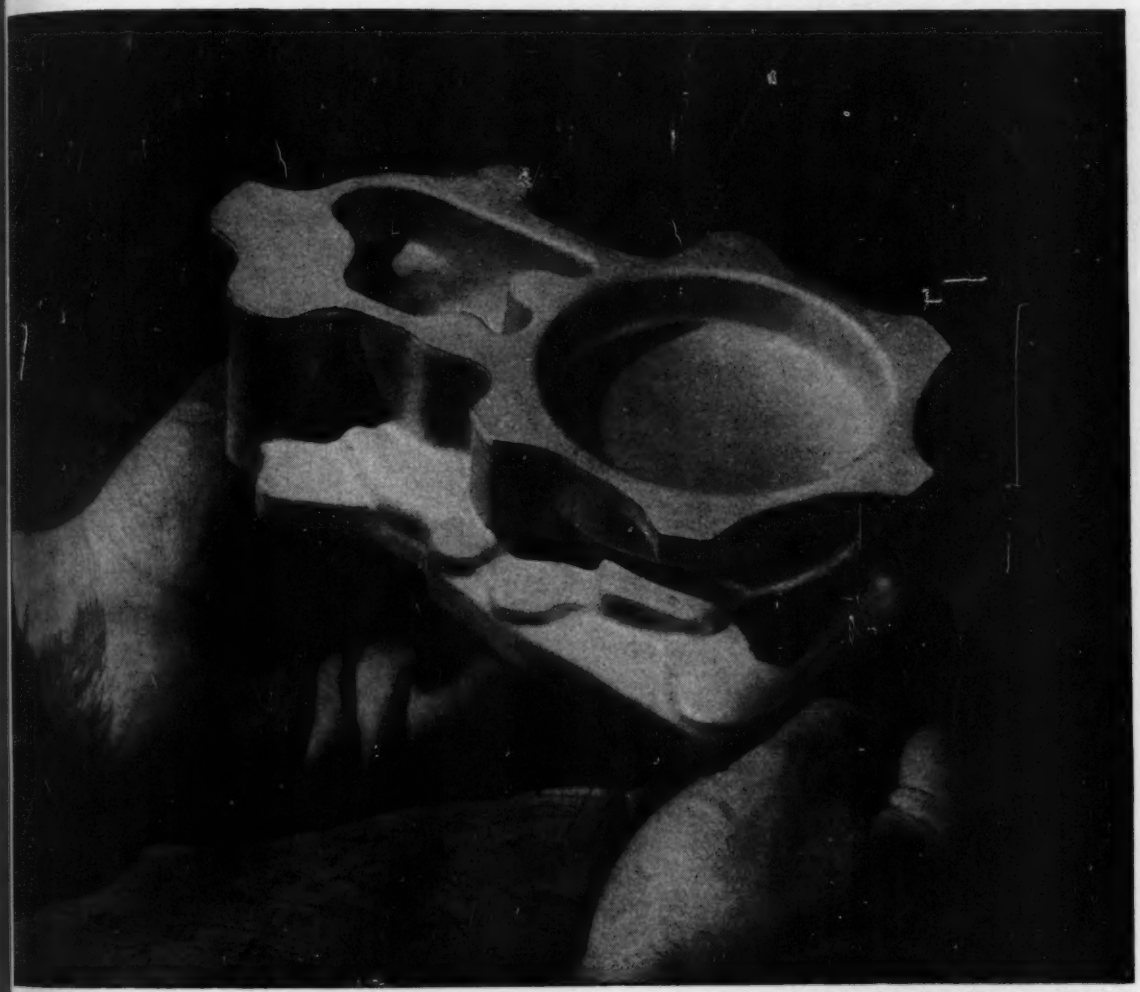

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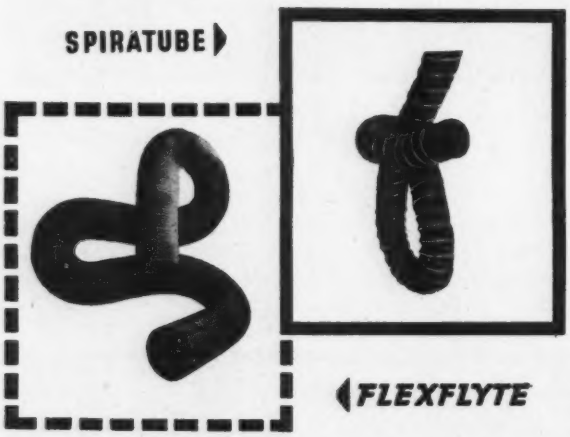

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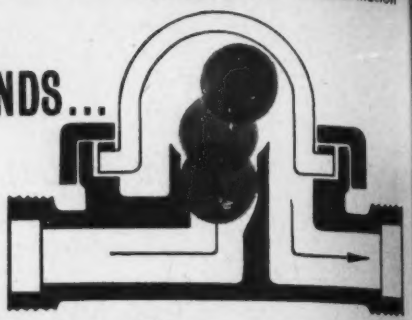

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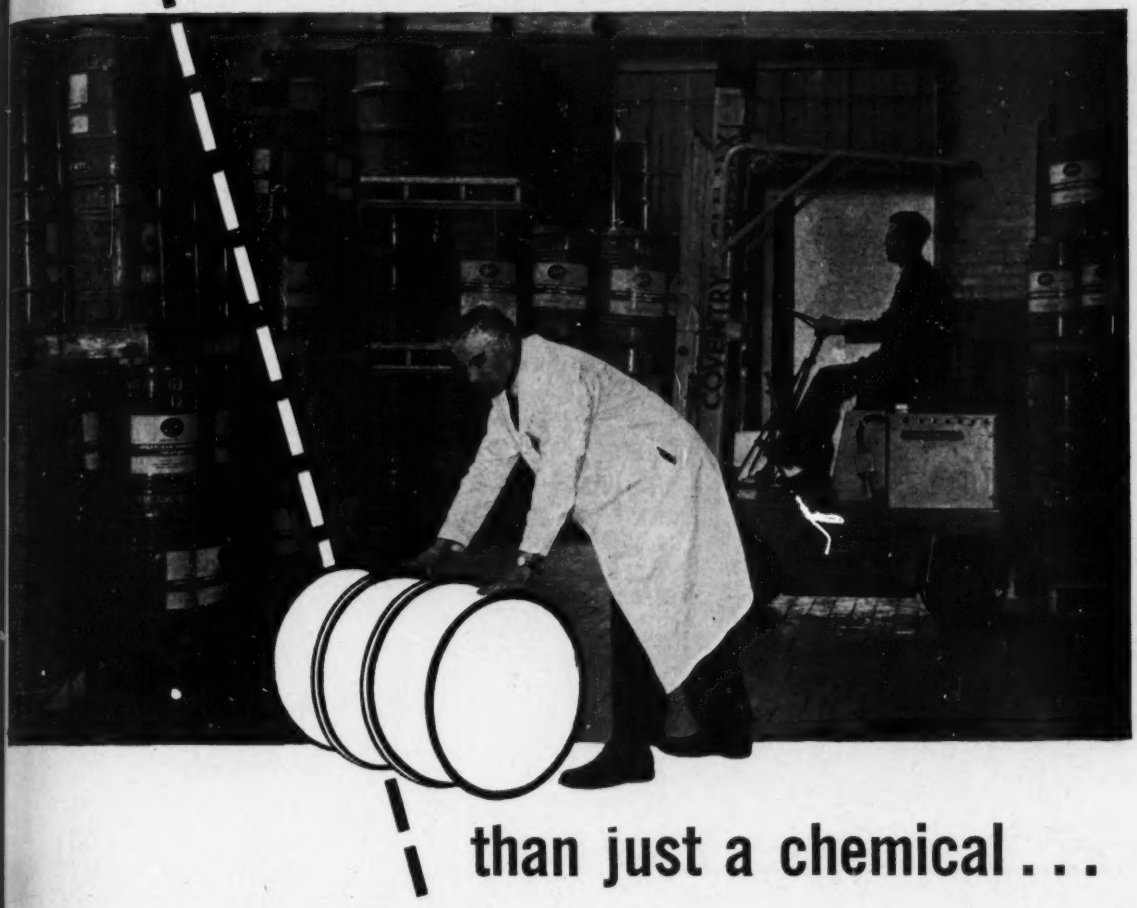

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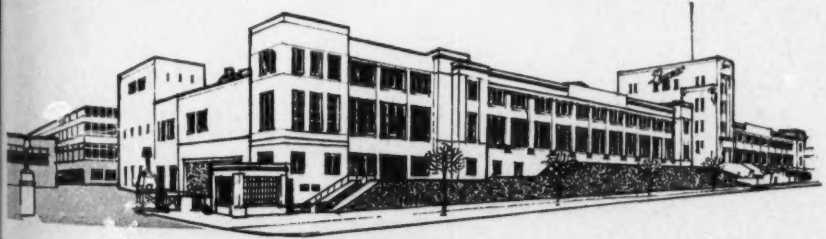

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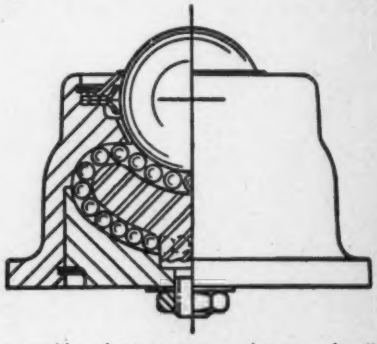

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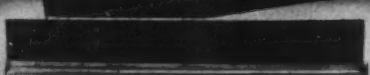

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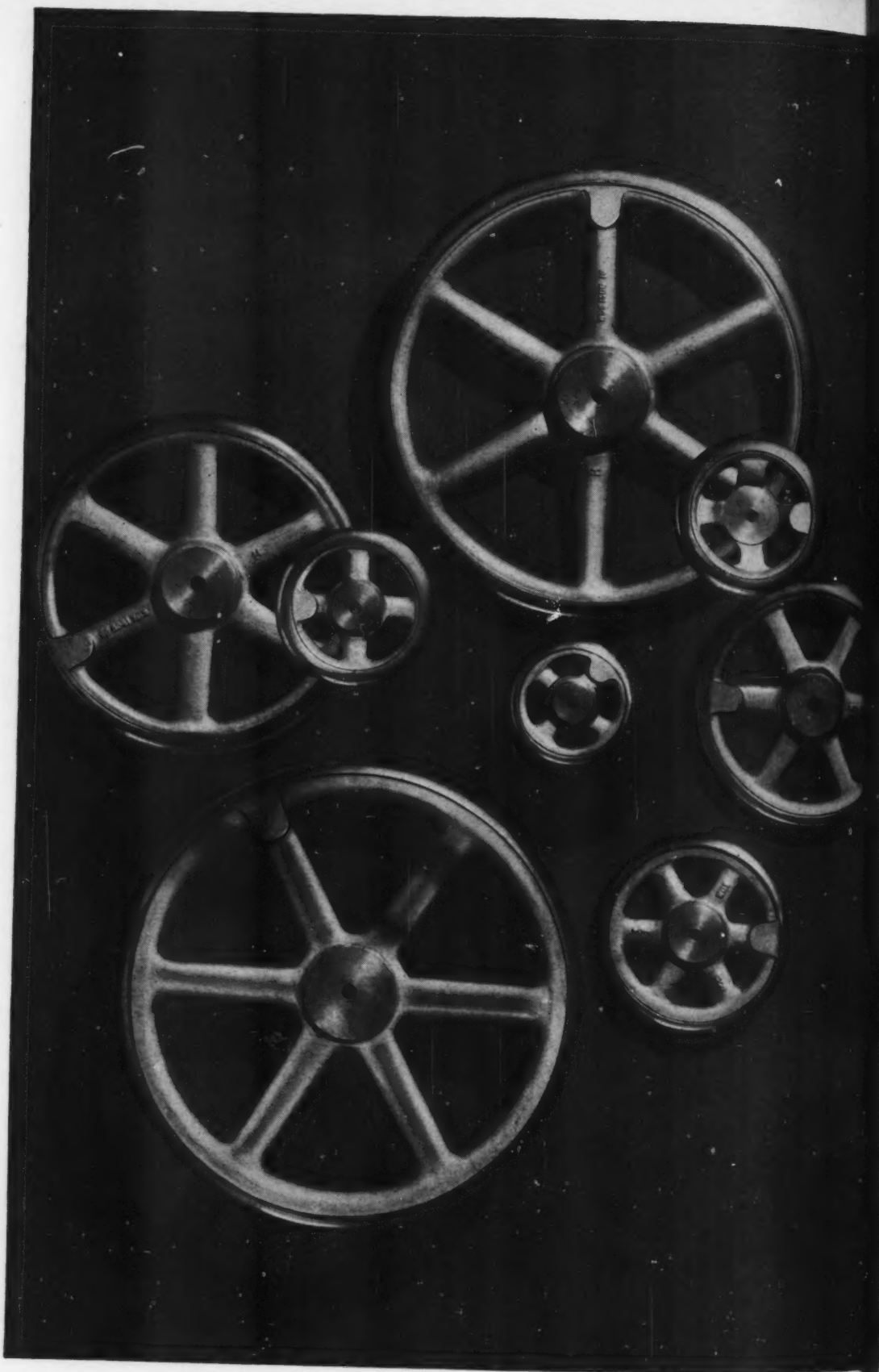

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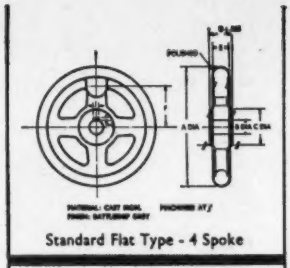
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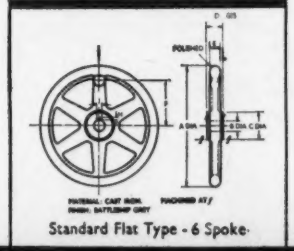
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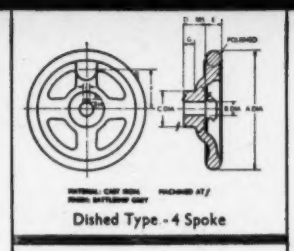
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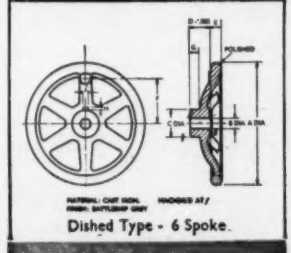
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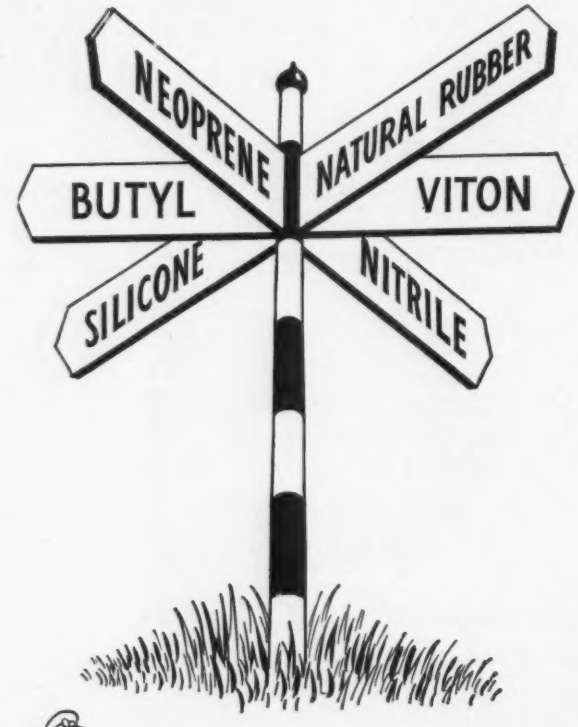

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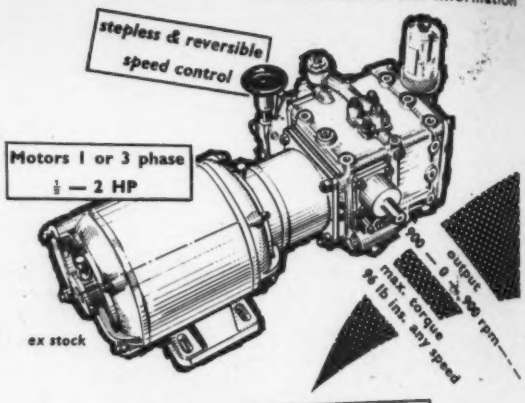

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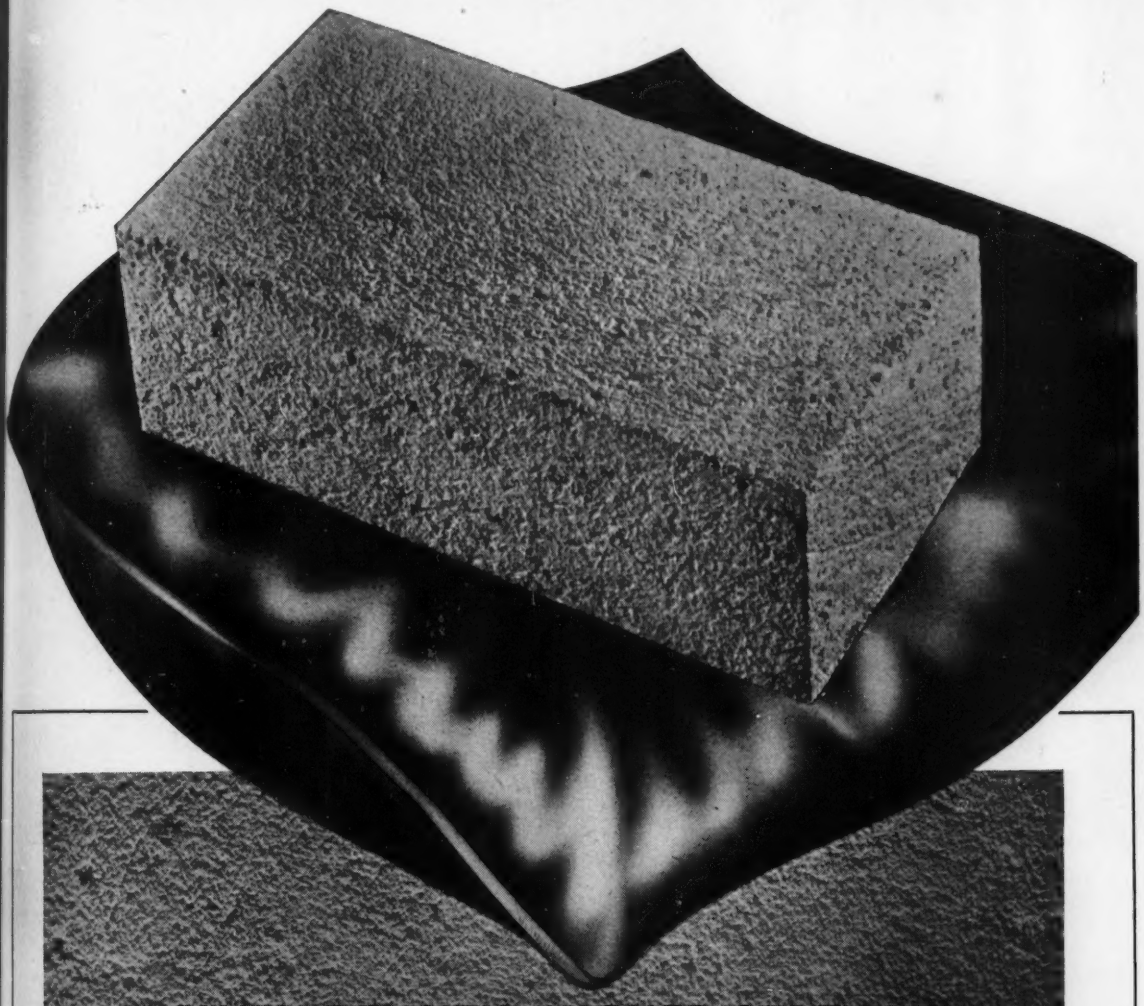

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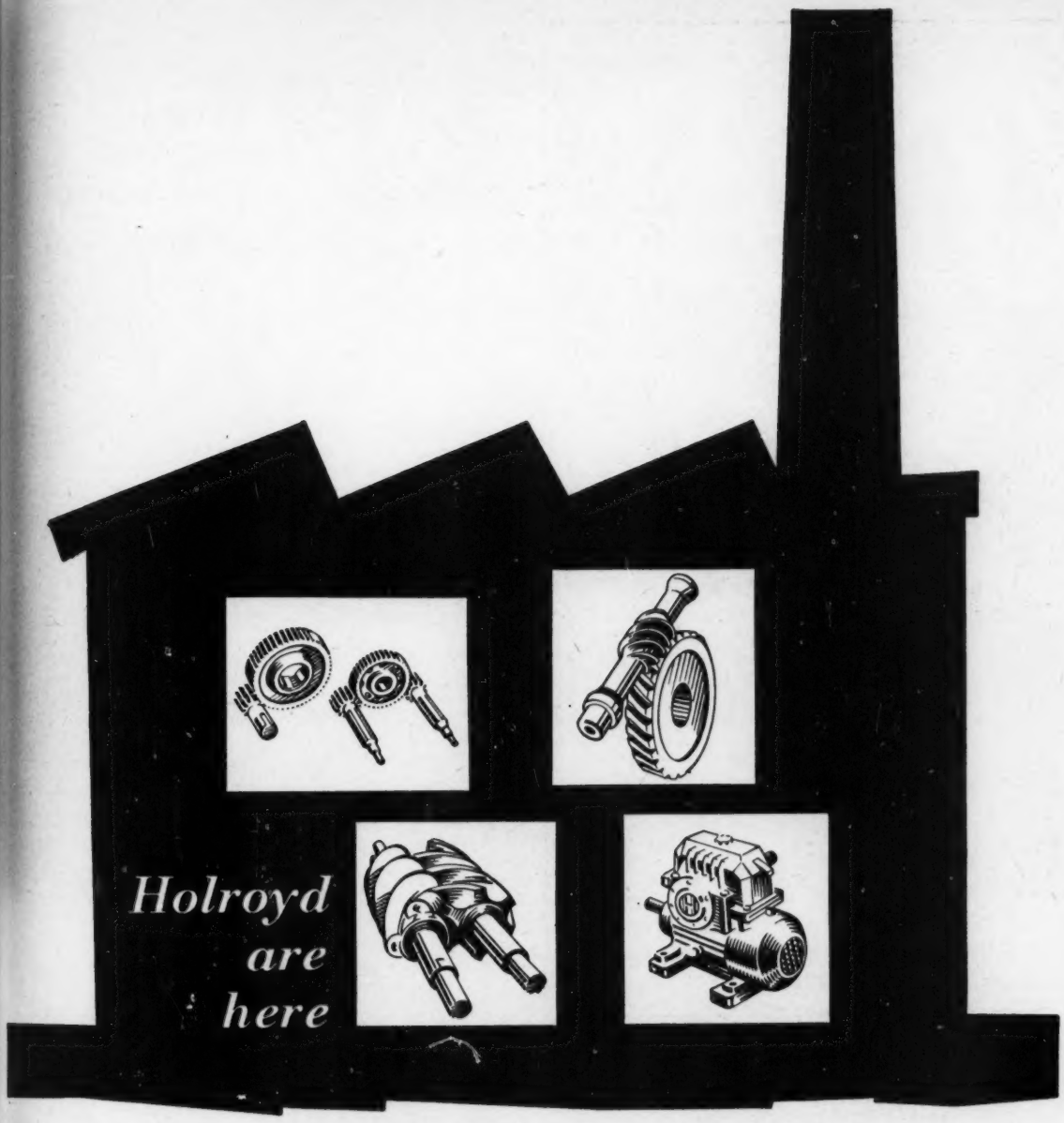
MSR 1



In industrial works all over the world, Holroyd products play a part in manufacture and distribution. Their unfailing reliability based upon a century's experience in forward-looking engineering, has made Holroyd a famous name in their specialised branch of engineering. Technical advice, practical service and distribution abroad are available from representatives in more than thirty countries all over the world.

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A quick, cheap, simple fastening

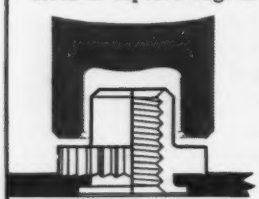
THE ROSAN PRESS NUT

does not require riveting over

The Rosan Press Nut is cheaper, easier and faster than other methods of providing tapped holes in sheet or plate. The same size Rosan Nut is suitable for any thickness of sheet. 'There is no maximum sheet thickness'.

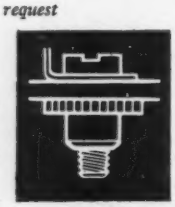
HOW IT WORKS

Punch or drill round hole in sheet metal to specific diameter. Insert smaller flange into hole. Apply impact force to exposed edge of serrated flange of Press-Nut.



Note that impact flows sheet metal into space between flanges, locking the Press-Nut securely in place. Teeth of the serrated flange broach themselves into the parent metal preventing rotation.

Leaflet and samples sent on request to the manufacturers:—



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When you stick anything—and we mean *anything*—with 'Eastman' 910 Adhesive it *stays* stuck.
No catalysts, no excessive pressure, no heat, rapid set time, extremely strong bond.

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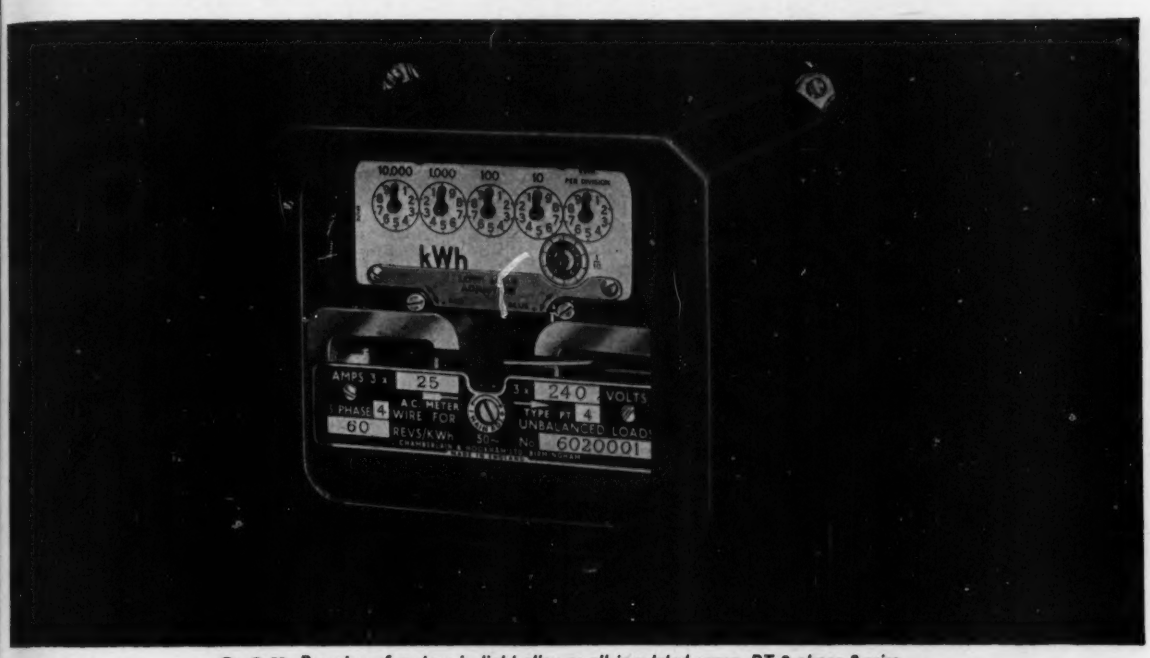
EMD 8219 for further information

choose C. & H. meters

for high performance in a compact size



***C. & H.** P series of meters in light alloy or all-insulated cases. PT 3-phase 3-wire. PT4 3-phase 4-wire. 5, 10, 25 and 50 amperes.*

POLYPHASE-SINGLE DISC TO BS37 Parts 1 & 4

There is a Chamberlain & Hookham meter for every purpose and every situation. These are the widely used P series of meters with single disc, specially designed to reduce errors due to interaction. Like all C. & H. meters they provide high performance in a compact size.

TRANSFORMETERS

C. & H. P type "transformeters" are of light alloy or all-insulated construction with steel transformer cases. PTU 3-phase 3-wire. PT4U 3-phase 4-wire. 100, 150, 200 and 300 amperes.

PTU

PT4U

CHAMBERLAIN & HOOKHAM LIMITED

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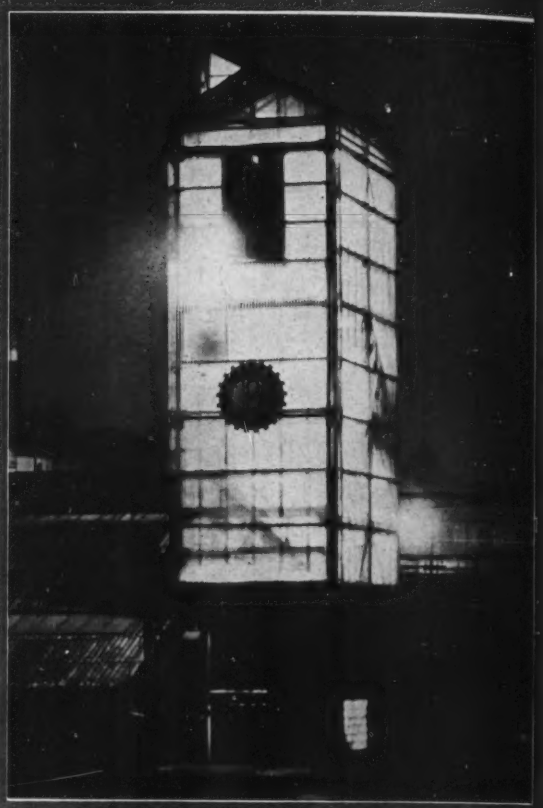


F. W. Berk & Co. Ltd., erected this tower in corrugated transparent Cobex to house a complex chemical process at their Stratford Works. The sign is made of opaque black and yellow Cobex sheet.

Cobex for corrosion resistance

COBEX rigid vinyl is tough, non-inflammable and dimensionally stable. It resists most chemicals, including mineral acids and alkalis. It is produced in transparent and opaque colours as well as clear transparent and translucent white. There is also a special outdoor range of lightfast colours and a translucent ceiling grade. Cobex can be used in deep draw moulding, and vacuum or drape forming. It is joined by hot gas welding.

COBEX is supplied in sheet or calendered rolls, and extruded sheeting. There are also various multi-colour laminated sheets for engraving.

BX PLASTICS LIMITED
The British Xylonite Group
BRANTHAM,
MANNINGTREE, ESSEX.
Telephone: Manningtree 401

TA.5571

EMD 8224 for further information

Post Office STAMPS on waste

METCO SAVES G.P.O. THOUSANDS

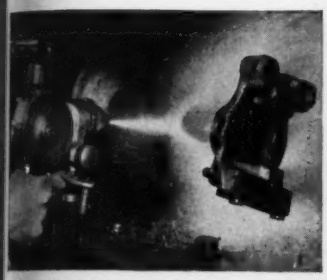
The G.P.O. repair depot at Yeading, Middlesex has a big job to do. It is responsible for keeping in good repair all the G.P.O. vehicles in the London and Home Counties area. Throughput of vehicle rebuilds is over 1,500 a year and over 2,250 engines a year arrive at Yeading for reconditioning.

By installing METCO flame spray equipment they estimate that thousands of pounds have already been saved by salvaging worn parts which were previously scrapped.

Why not let Flame-spraying help increase your profits? It can in many ways—salvaging worn parts, hard facing original equipment for increased life, or zinc or aluminium spraying for corrosion protection.

A booklet giving Engineering Data on Flame-Sprayed coatings is available from METCO. Please complete or pin the coupon below to your letterheading and send it for your copy.

Here, the metallized crankshaft is ground to standard size. In service it will give longer life than original.



The metallizing department at the G.P.O. repair depot handles a wide variety of undersize components. Typical, is the stub-axle which is being rebuilt on the bearing-fit diameters.

After two or three regrinds, these crankshafts would previously be scrapped. Now the journals and pins are rebuilt to "as new" diameters at a fraction of their replacement cost.

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REGISTERED USER

METCO LTD *FORMERLY: METALLIZING EQUIPMENT CO. LTD.*

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Telephone: Chobham (Woking) 590

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METCO LTD Chobham Woking England

Please send information on Flame-Spraying.

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COMPANY .....

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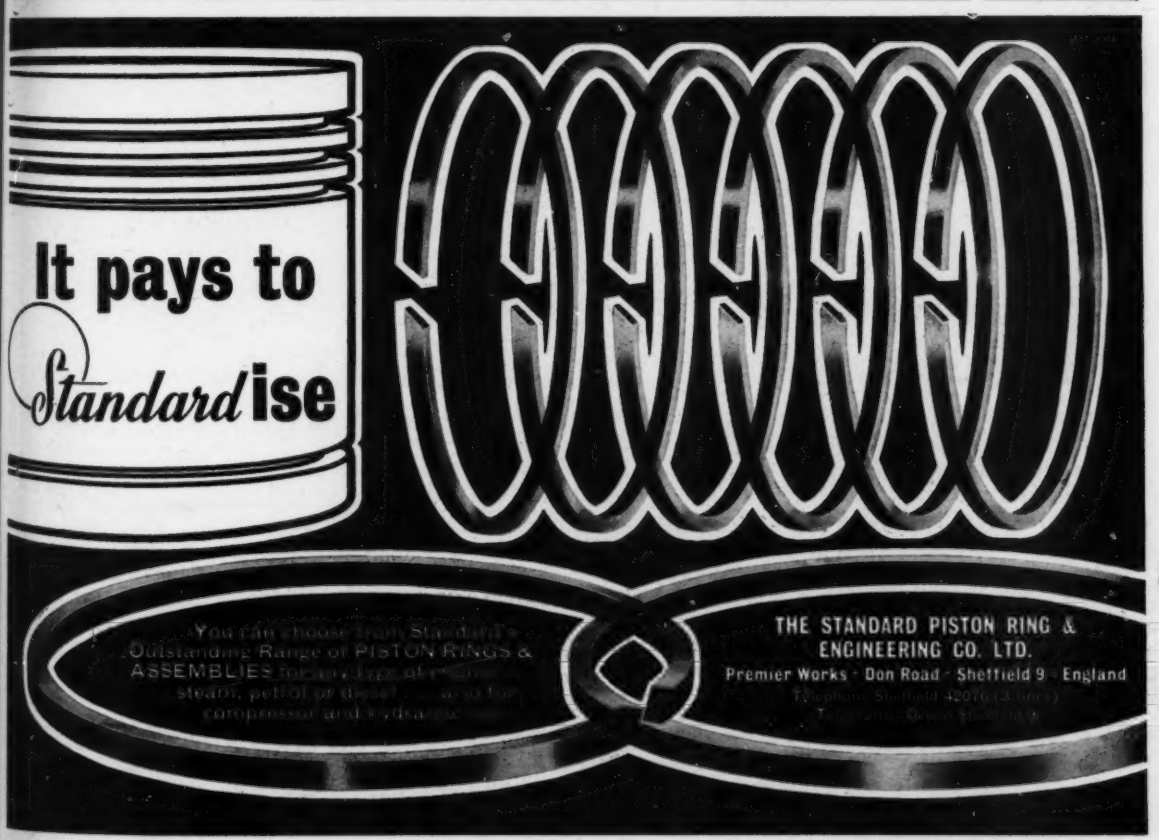

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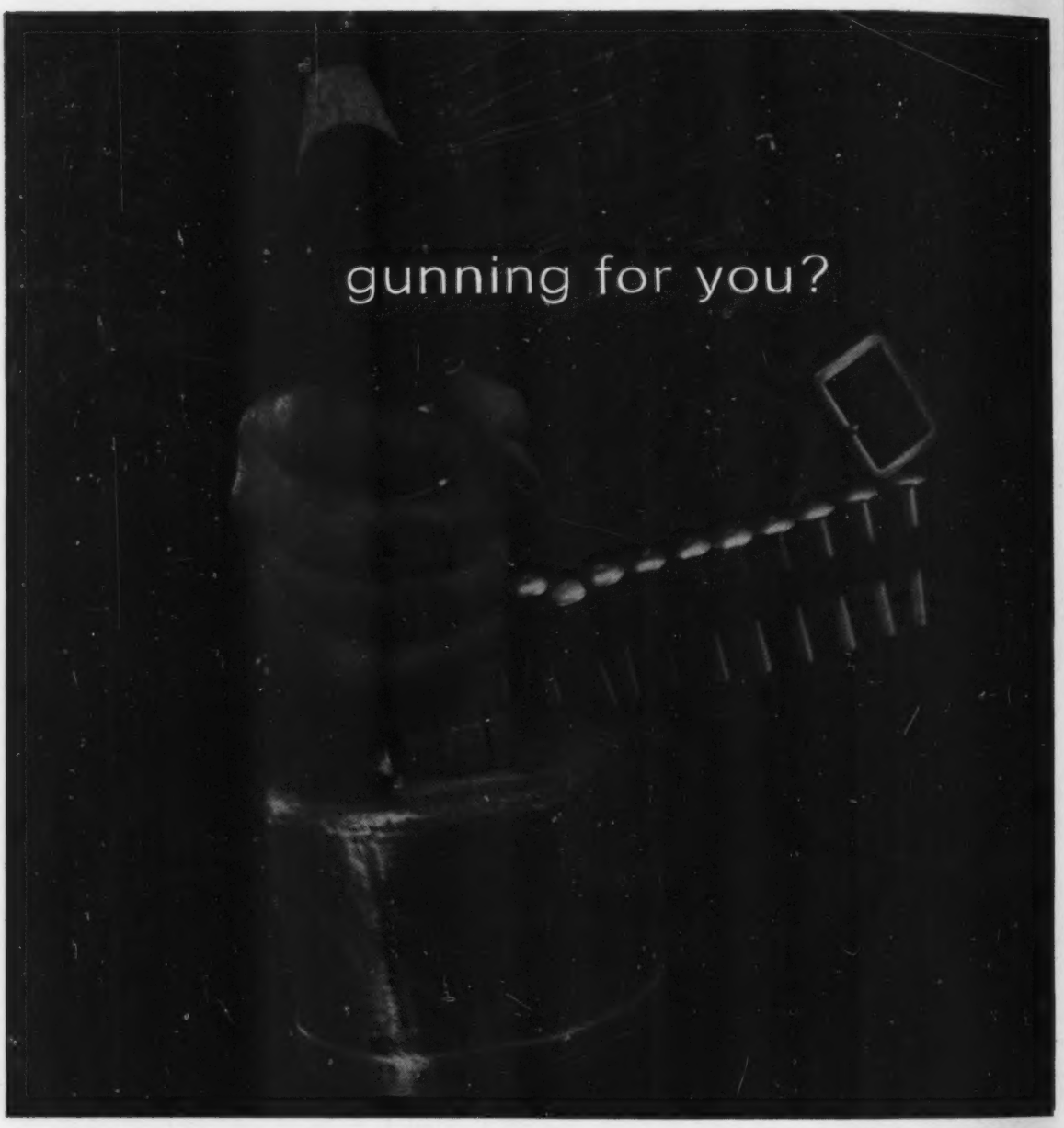
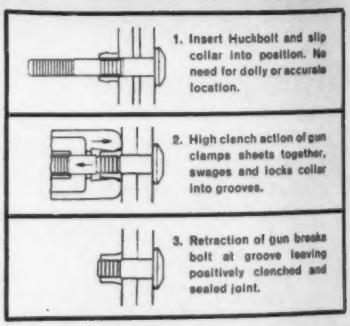


Thought about what your competitor's up to lately? How, for instance, he turns out the goods more quickly and cheaply than you do? And a pretty solid job at that . . .

Well, let's just ask a question or two. Like, how do you fasten metal parts or sheets? . . . Nuts? Bolts? Solid Rivets? If you've said yes, read on. Now—nip into that awful fellow's factory and have a snoop around. If he menaces you with one of those guns, he's done you a favour. Now you know he's operating the Huckbolt high speed fastening system, you are armed. And if you can't fight it, join it! Huckbolts do a superior job quicker and at less cost. Don't take our word for it! Try the HUCKBOLT system on your own job under normal operating conditions. Just phone or write to Avdel.


1. Insert Huckbolt and slip collar into position. No need for dolly or accurate location.
2. High clench action of gun clamps sheets together, swages and locks collar into grooves.
3. Retraction of gun breaks bolt at groove leaving positively clenched and sealed joint.

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MS FLUID FACTS

How much do you know about SILICONE FLUIDS

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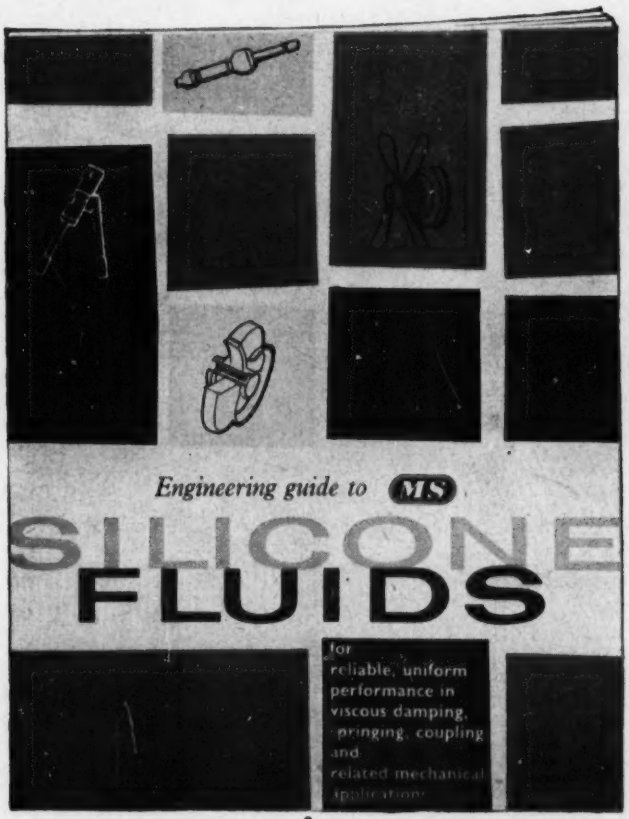
Did you realise that they have:

- *Exceptional thermal stability*
- *Excellent viscosity temperature characteristics*
- *Extreme resistance to oxidation and shear breakdown*
- *Low volatility*
- *High flash points*

No? Well why not find out more about these versatile fluids and the way that they are already being used by industry. Our publication 'Engineering Guide to M S Silicone Fluids' (G 11) sets out numerous application examples and gives further particulars of the properties—why not write for a copy today—now!

If your requirement is more for silicone lubricants and greases then 'Silicone Lubricating Fluids & Greases' (G 14) *is the publication for you.*



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MIDLAND SILICONES LTD

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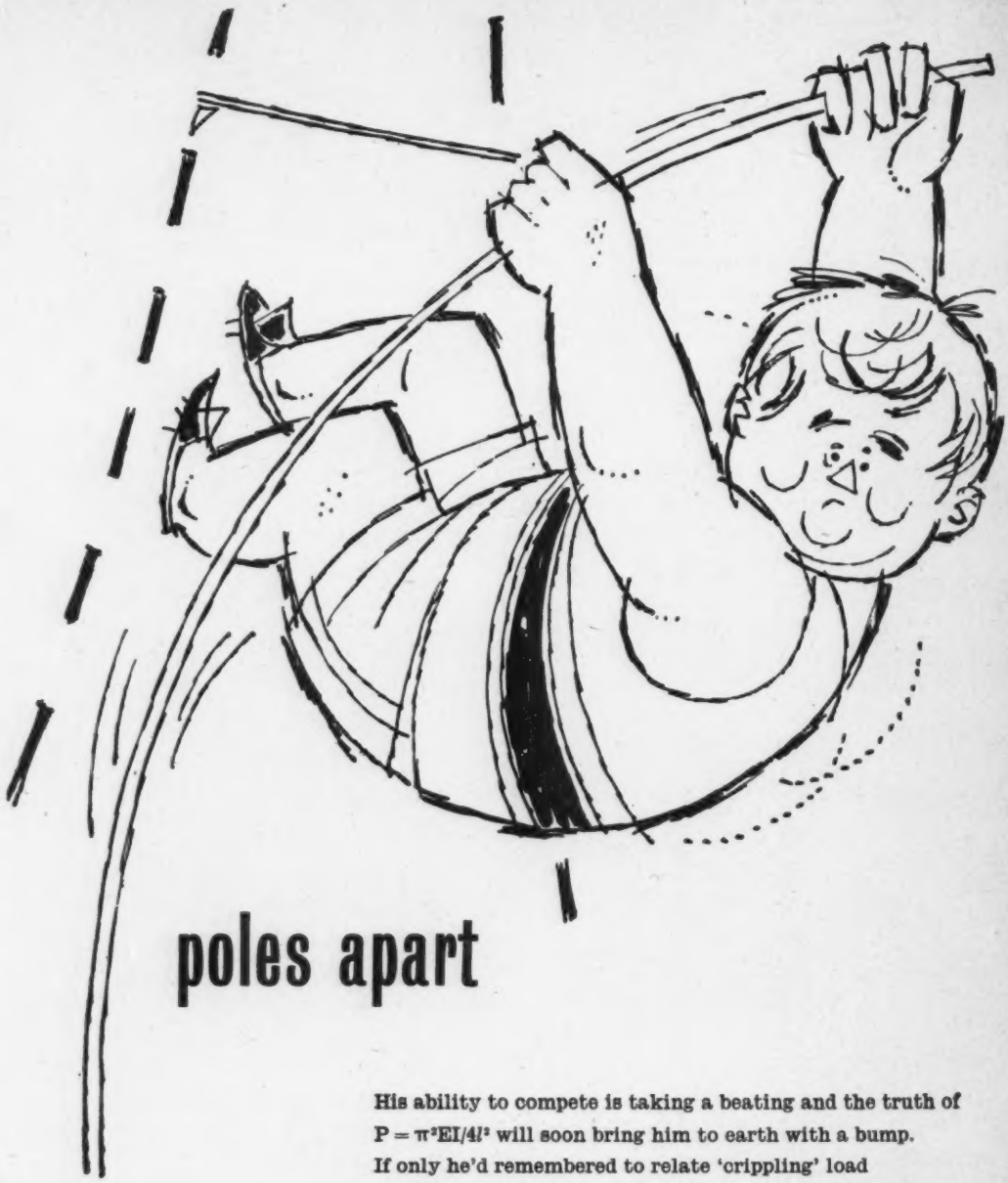
MSF8



poles apart

His ability to compete is taking a beating and the truth of $P = \pi^2 EI/4l^2$ will soon bring him to earth with a bump. If only he'd remembered to relate 'crippling' load with length, modulus and cross section . . . He'd have been 'at one' with designers who choose versatile magnesium for struts and columns.

The lightest structural metal, magnesium offers all the strength, stiffness and resilience, an ability to beat competition wherever it is used.

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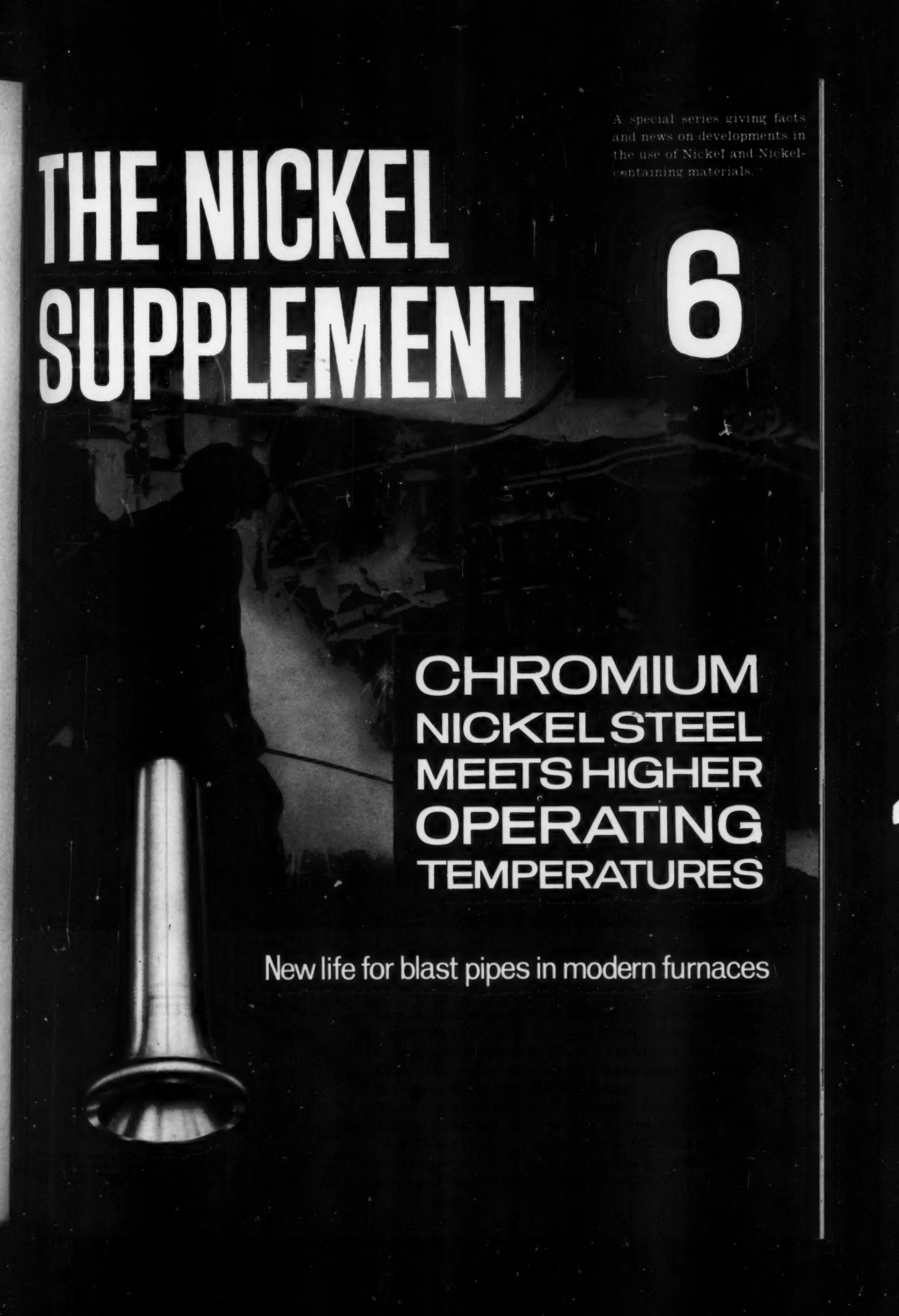
THE NICKEL SUPPLEMENT 6



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New life for blast pipes in modern furnaces

MEETING CORROSION IN STEAM CONDENSERS

A condenser for the 500-MW Hinkley Point Nuclear Power S

Cupro-Nickel tubes for two atomic power stations

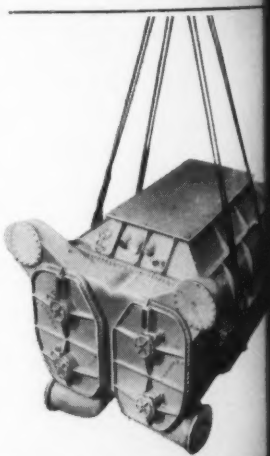
In two of Britain's newest nuclear power stations, Berkeley and Hinkley Point, 70/30 type cupro-nickel is used for the condenser tubes to overcome problems of wear and corrosion. At Hinkley Point alone, Yorkshire Imperial Metals Limited have supplied 84,000 tubes of this material weighing some 542½ tons.

Lighter tubes, higher efficiency

Cupro-nickel is noted for its outstanding resistance to the corrosion encountered in coolants drawn from rivers, estuaries and coastal waters. Because it is highly resistant to impingement attack, it permits the use of thinner tubes with higher water-flow speeds.

The standard 70/30 cupro-nickel contains less than 1 per cent of manganese and iron. Another alloy of the same type with the manganese and iron increased to 2 per cent, known as Yorcoron/Kunifer 30A, is used for the two atomic power stations. This type is particularly resistant to the abrasion, caused by cooling water containing sand or other abrasive solids, as in the Severn Estuary.

Cupro-nickel was first used extensively nearly forty years ago at Newcastle-upon-Tyne Power Station. The continued specification of this material for Britain's newest and largest power stations is convincing proof of its efficiency.



Cupro-nickel is extensively used ships' condensers. This installati used in S.S. Canberra

THE NICKEL SILVER SERIES OF ALLOYS

low cost alloys with all these perties:

GOOD ELASTIC MODULUS

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FIRST CLASS FORMABILITY AND MACHINEABILITY

VERY ATTRACTIVE APPEARANCE

NO PLATING DIFFICULTIES

These alloys are used in:

Small Instrument and Engineering Components, because they produce strong, corrosion-resistant component parts at a low cost.

Telecommunications and Electrical Equipment, because of their corrosion-resistance and high modulus of elasticity.

Architecture, because of their strength, hardness, corrosion-resistance and particularly, the range of colours available, from pale gold to silver white.

Cutlery and Hardware, because strength and corrosion resistance are allied to good forming properties and ease of electro-plating.

COMPOSITION AND PROPERTIES OF THE NICKEL SILVER ALLOYS

Description	Composition (per cent)			Max. Stress t.s.i.		Proof Stress t.s.i.		Elongation 2" per cent		Modulus of Elasticity	D.P.N.	
	Ni	Cu	Zn	Annealed	Cold Rolled	Annealed	Cold Rolled	Annealed	Cold Rolled	Millions of lb/sq. in.	Annealed	Cold Rolled
B.S. 790-1938 Sheet and strip	10	60—65	25	22.0	44.0	6.5	38.0	65	5.0	18	69	208
	12	60—65	21	22.0	45.0	7.0	38.0	60	4.0	18	77	209
	15	60—65	20	23.0	45.0	8.0	40.0	55	4.0	18	73	207
	18	60—65	17	25.0	45.0	7.7	40.0	52	5.0	18	81	208
	20	60—65	14	24.0	45.0	8.0	40.0	50	4.0	18	91	207
	25	55—60	13	25.0	45.0	8.0	40.0	50	4.0	18	89	198
	30	55—60	8	25.0	42.0	8.0	38.0	48	5.0	18	92	198
B.S. 1824-1952 Nickel Silver strips & foil for the telecommunications industry	12	60—65	22—29	23.0	40.0	7.5	34.0	43	3.0	17	—	180
	18	54—56	25—29	25.0	50.0	10.0	45.0	48	3.0	19	93	220
Hot working extruded rods and sections	10	45	45	41				28			155	
	12.5	45	42.5	35				42			132	
	15	45	40	36				41			168	

Send for the publications that interest you

An illustrated journal for engineers, featuring interesting applications of nickel-containing materials.

A monthly journal containing abstracts of information published by learned societies, research organisations and technical journals from all parts of the world, on the metallurgy and chemistry of nickel.

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935 Thermal Expansion of Steam Valve Materials

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367 Nickel Alloy Steels, Design Data for Shafts
1268 Nickel Alloy Steels, Transformation Characteristics
468 Nickel Alloy Steels, Mechanical Properties
233 Nickel Alloy Steels for Machine Tools
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149 Nickel Cast Iron for Engineers
107 Ni-Resist in the Chemical and Allied Industries
736 Ni-Hard: Properties and Applications
1548 S.G. Iron: Properties and Applications
1594 S.G. Iron in Steelworks Plant

NICKEL PLATING
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E.D.12

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(Formerly The Mond Nickel Company Limited)

EMD 8108 for further information

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AIMS AND OBJECTS

1. *To promote, encourage and improve design in all branches of engineering and allied technologies.*
2. *To foster and facilitate the interchange of information, ideas and practices by holding conferences, visits and social meetings. Visits will include factories, research organisations and international events.*
3. *To stimulate discussions and the practical interpretation of theoretical and other aspects of design.*

PROVISIONAL PROGRAMME 1962

A One-day Symposium will be held at Buxton, Derbyshire, on the 22nd March, 1962. There will be three papers in the morning as follows:—

THE DESIGNERS PROBLEMS, by W. T. Davies, Esq., of Aero Engine Division, Rolls-Royce Laboratories.

ALLOY STEELS, by Dr. Irvine of Swinden Laboratories, United Steel Companies Limited.

STAINLESS STEELS, by J. I. Morley of Firth-Vickers Stainless Steels Limited.
A works visit to Firth-Vickers Stainless Steels Limited has been arranged for the afternoon.

May, 1962
The A.S.M.E. Design Engineering Conference & Exhibition held annually in the U.S.A. draws engineers and designers from all over the World, and members of the Association will receive details of facilities for travelling to Chicago for the 1962 Conference and Exhibition.

Autumn, 1962
A Three-day Symposium will be arranged in the West Country. The theme will be the "Selection of material as seen by the designer, production engineer and sales staff", and will cover both consumer products and a more specialised form of engineering. The full programme including costs will be announced at the Engineering Materials & Design Exhibition.

For Details write to:—

THE SECRETARY,

ENGINEERING MATERIALS & DESIGN ASSOCIATION,

DRURY HOUSE, RUSSELL STREET, W.C.2. *Telephone: TEMple Bar* 3422

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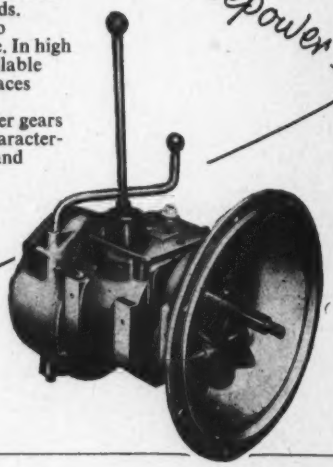

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low cost
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almost
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or shape
high impact resistance
impervious to fumes
and corrosion
high strength-
weight ratio

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Tool costs for both processes are relatively low.

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of steel per week—pickled. In a single acid bath or continuous lines handling 72" strip at 400 ft./min.

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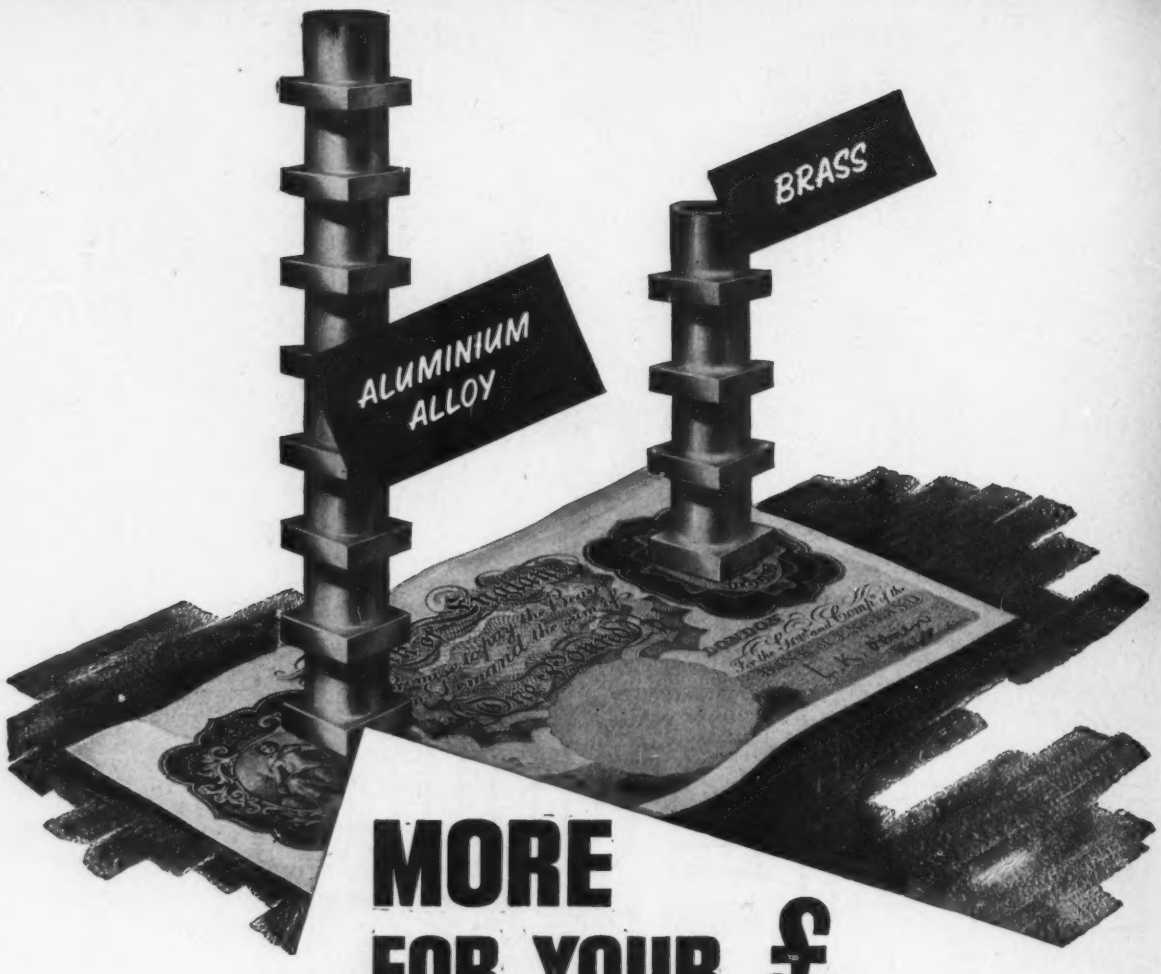

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Small chips eliminate swarf "build up" at tool tip.

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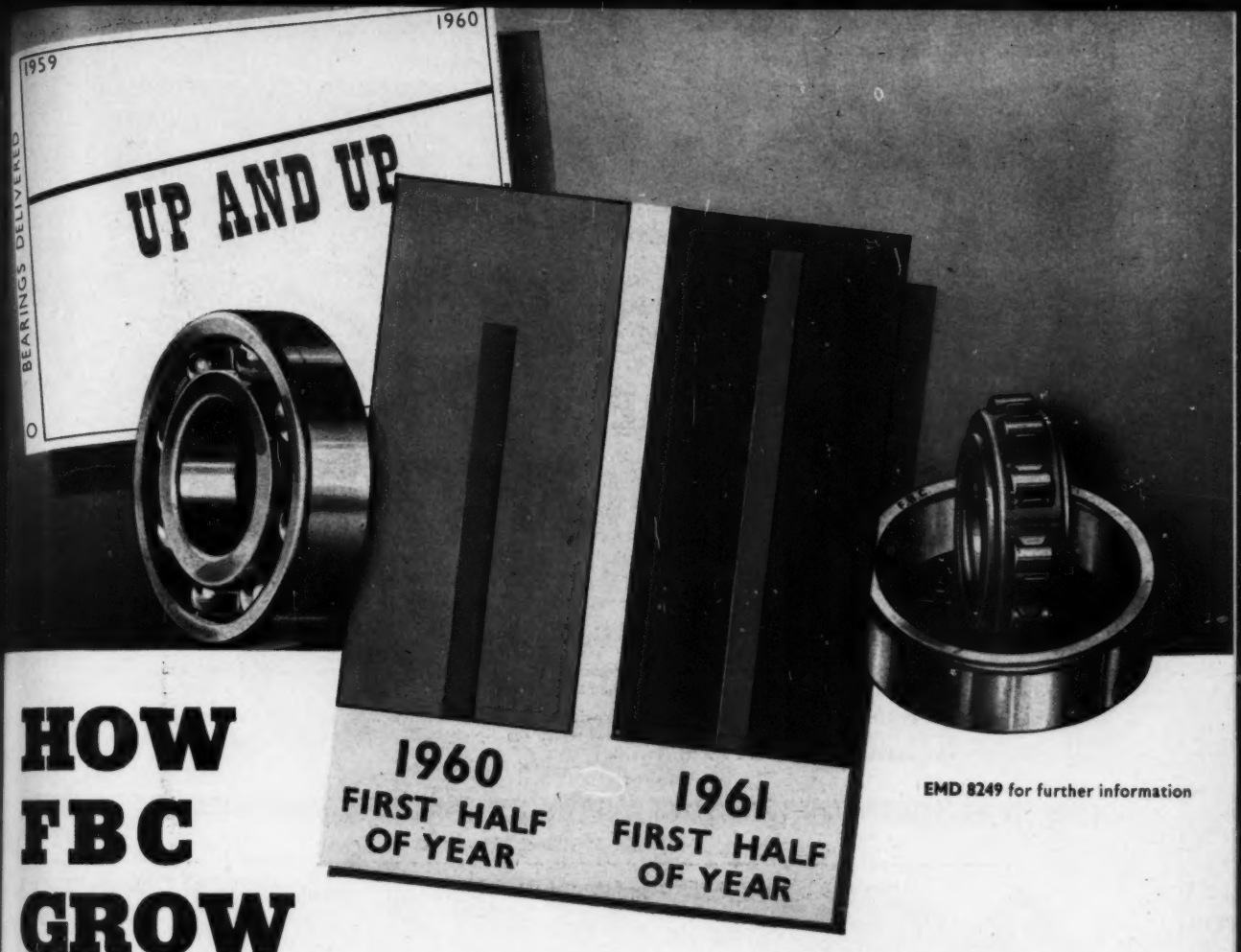

HOW FBC GROW

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It isn't long since we showed, in one of our advertisements, the great increase in turnover last year.

Here's another figure that proves how our increased service to industry is still bearing fruit :—

In the first half of 1961, sales of bearings were 25% greater than in the corresponding period of 1960!

The wisdom of our new policy is thus confirmed by the demand for our additional range of bearings and transmission equipment.

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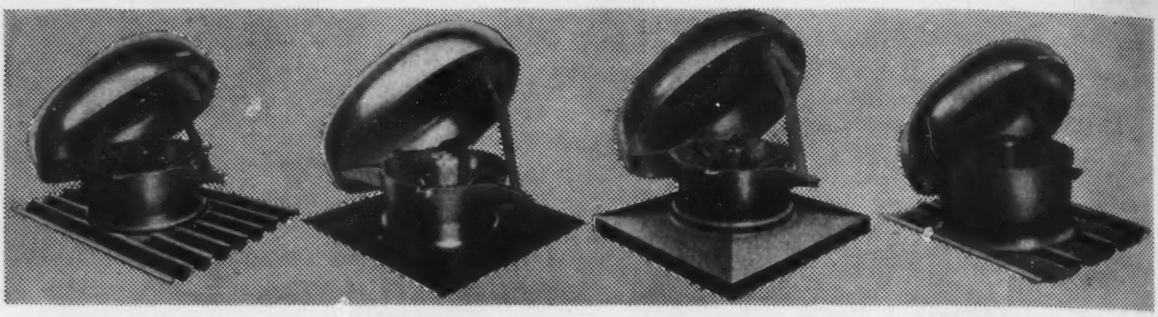

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★ WILL NOT CORRODE
★ STRUCTURALLY PERMANENT
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★ HINGED COWL FOR EASY ACCESS
★ NO SPECIAL ROOF TRIMMERS

The basic material used in the body and cowling resists attack from most industrial processes and even from oxidising acids when diluted by the normal workshop atmosphere.

The design suits any pitch of roof, together with horizontal or vertical mounting. A special feature giving ease of maintenance is the hinged cowl which readily exposes the motor for servicing and an enclosed cable duct protects electrical work.

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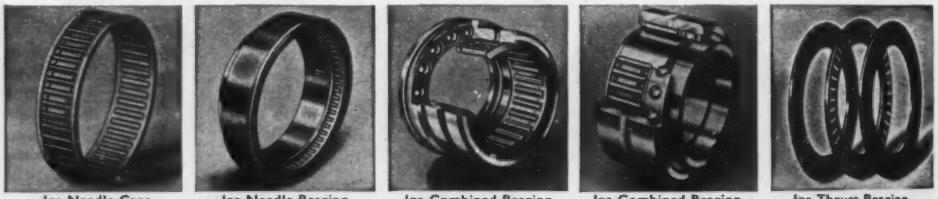
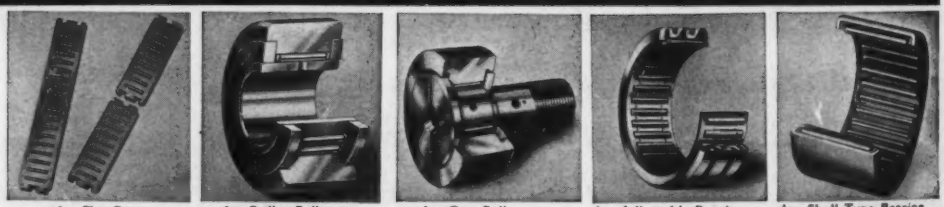


Ina Needle Cage | Ina Needle Bearing | Ina Combined Bearing (NKX Series) | Ina Combined Bearing (NKIB Series) | Ina Thrust Bearing

CAGE GUIDED NEEDLE BEARINGS



Ina Flat Cage | Ina Roller Follower (NATR Series) | Ina Cam Follower | Ina Adjustable Bearing | Ina Shell Type Bearing

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- Even load distribution with maximum rigidity of mounting.
- High peripheral speeds.
- Bearings range from shaft diameters of 4-390 mm.
- Over 3,000 types and sizes kept in stock.

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Ina Bearings are manufactured in Great Britain, France, Brazil and Western Germany.

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Our local technical representative is at hand to advise you. Write for your free copy of the Ina Technical Handbook and Comprehensive Catalogue L.301.

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Better to be Safe...

than sorry!

When designing components specify BRALLOY products and be sure.

Strength and reliability in service are demanded of the pressings used for the buckle on this car safety strap. BRALLOY hot pressings have these qualities and the added advantages of less machining and lower polishing costs when compared with castings.

Photographs by courtesy of IRVING AIR CHUTE OF GREAT BRITAIN LTD., LETCHWORTH, HERTS

Find out more about BRALLOY products by sending for our new brochure. It contains useful information for all designers and buyers and may suggest how BRALLOY products can be used in even more industrial projects.

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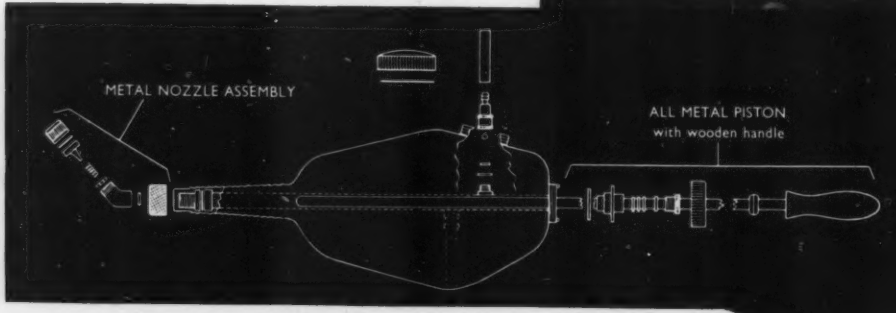
Lacrinoid prove it with **RIGIDEX** *polyethylene*

That blow moulding can be an easy, speedy, inexpensive way of converting plastics is widely known. That it is also a *precision* process is now clearly shown by the 'Plafog' sprayer. The design specification called for the attachment of metal fittings to the moulded body— the nozzle itself, a spray disc within the nozzle and bronze valves on the ram pump. Tolerances were fine throughout. That blow moulding could achieve them with such an 'individual' design is a tribute to the process. That Rigidex could contribute, here as elsewhere, the required strength, lightness, rigidity and resistance to corrosion is proof indeed of the properties that make it—today's leading high density polyethylene.

For detailed information about Rigidex, write today for Booklet No. 317

Container of Plafog sprayer blow moulded in Ridigex by Lacrinoid Products Ltd. for Cooper, Pegler & Co. Ltd.



Rigidex is a reg'd trade mark of British Hydrocardon Chemicals Ltd and one of the products they manufacture at Grangemouth.

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Harpers will be pleased to send you a booklet which describes their castings in SG iron, grey iron and Harper-Meehanite (the word 'Meehanite' is a registered trade mark). On Lloyd's List for SG iron and Meehanite castings. Metal pressings, machining, enamelling and sub-assembly work are all part of the Harper service.

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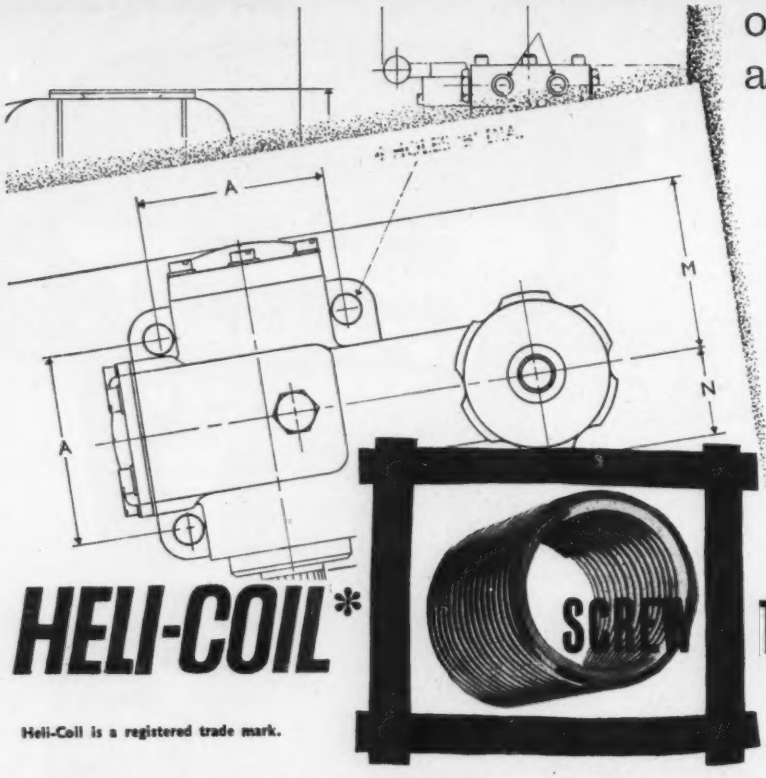

ordinary threads are no longer sufficient.....

The simple embodiment of Heli-Coil screw thread inserts in the product is a discriminating step at the design stage. Unprotected threads are no longer sufficient.
By using Heli-Coil individual high tensile stainless steel threads in the place of normal threads, weight in the product is cut down. At the same time higher load strength is added. More rigid resistance is given against stress, wear and strain, and shorter, less bulky thread engagements are permitted. No bosses, flanges or oversize wall thicknesses are needed; the part is simply drilled and tapped and the Heli-Coil screw thread is installed.
The appearance and performance of the product are improved tremendously, with the result of a smooth, free running permanent thread which can be disassembled at any desired time in the future. Costs are reduced; enormous reductions are made in time and labour, and machining is a simple matter on the assembly line.

Full details are freely available in sales leaflet E.3.

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Produced specifically for CAPSTANS and AUTOS

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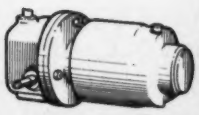
Nelson can put the right drive into your development project

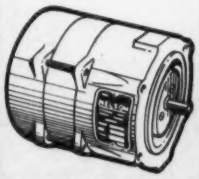
(or your production schedule)

The Nelson Engineering Company is equipped for the 'one off' or batch manufacture of special AC or DC electric motors up to 50 h.p. From their experience they can design a 'special'; adapt a B.S. rating, make to American 'specs' or alter one of their patented non-standard units to provide the right drive for your project. The Nelson Engineering Company are always prepared to discuss electric motors and related electric circuitry at any time from 'drawing board' onwards.

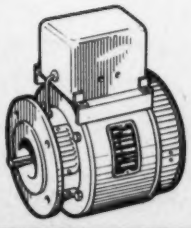
Below are illustrated five Nelson made electric motors. May we send you our catalogue 'Examples of Nelson Non-Standard Rotary or Static Electrical Equipment'?

A geared type unit, suitable for infinitely variable speeds on the output shaft (1 to 20), also suitable for operation in conjunction with 'Thyratron' type excitation.



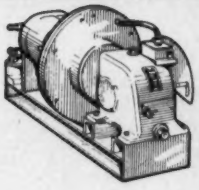


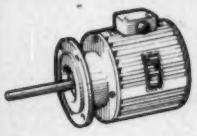
The gearless synchronous Hetropolar Motor was developed by the Company and has been widely applied in indexing and control applications. Gives true direct drive of 62.5 75/93.75 r.p.m. (50 cycles) 5-140 r.p.m. from V.F. needs no maintenance. Constant torque immediate stop/start reversal.



Used on the heating systems of B.R. Diesel Locos, the 2.5 h.p. D.C. Motor provides the forced draught for boilers; the transformer converts the supply to 10,000v. for the ignition circuitry.

Geared unit providing speed of .25 r.p.m. (output torque 200 lbs). The unit is fitted with automatic reversal switching and incorporates magnetic braking.





Made to B.S.S. but supplied with extended shaft and predetermined flange drillings. The shaft which is approx. 2' longer than the standard B.S.S.Motor is specially hardened.

NELSON

ENGINEERING COMPANY LTD.,
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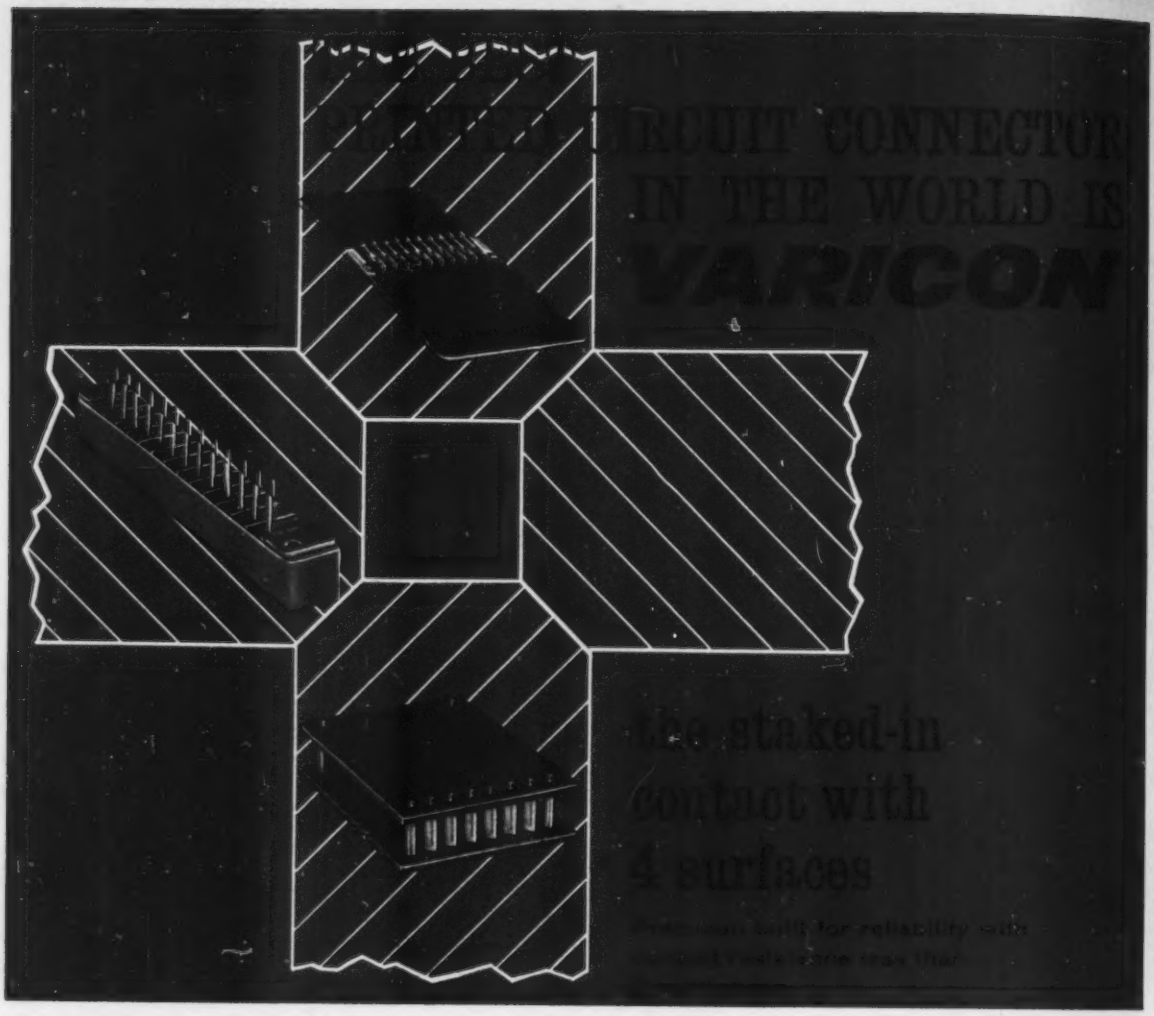
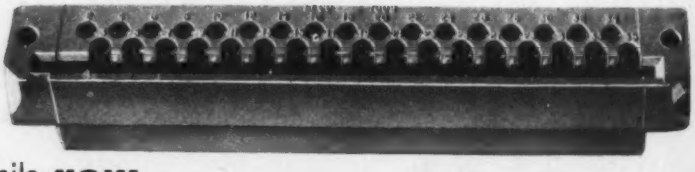


- Contacts automatically aligned without problems.
- Contact spacings available are 0.1″, 0.15″, 0.2″ and 0.3″.
- Furthermore, the Varicon Contacts can be used for direct board to board arrangement without any moulded socket. This offers maximum DESIGN FREEDOM.

The contacts are already proven by wide use in computers by **ELCO CORPORATION OF AMERICA.**



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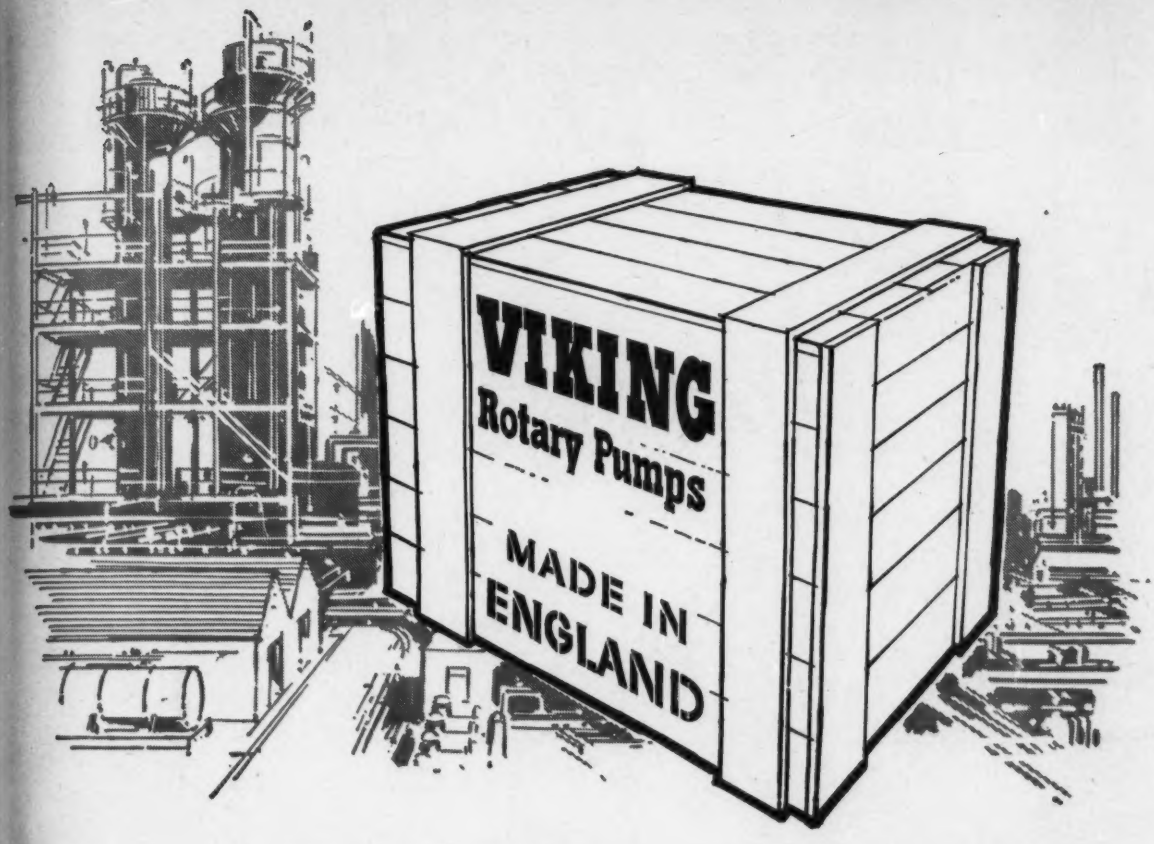
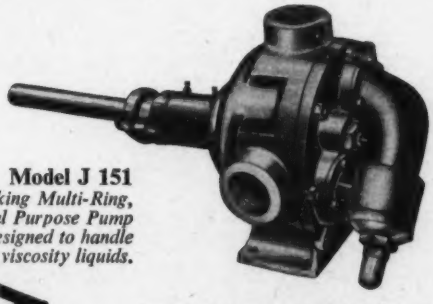


VIKING Gear-within-a-Gear Pumps are now made in England by Zwicky Ltd., Buckingham Avenue, Slough, under licence from the Viking Pump Company of Cedar Falls, Iowa, U.S.A.

The first-ever pump to be designed on this principle was manufactured by the Viking Pump Company at its Cedar Falls Works in 1911. *Now 50 years later there are over* **750 standard catalogued designs,** *and many custom-built VIKING PUMPS in operation throughout the World.*



Model J 151
A Viking Multi-Ring, General Purpose Pump designed to handle low viscosity liquids.

The full range of VIKING PUMPS extends from pumps of $\frac{2}{3}$ gallon per minute capacity up to designs delivering 1,050 gallons per minute — **minute** *not hour.*

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Zwicky Ltd., an old established Company, are specialist manufacturers of Pumps, Filters, Controlled Pressure Valves, Floating Suction Headers, Shut-off Valves, Bulk Loading Arms, Aircraft Refuellers and Dispensers, and other ancillary components of systems handling oil and related products, including bulk storage systems.

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ZWICKY LTD., Buckingham Avenue, Slough, Bucks

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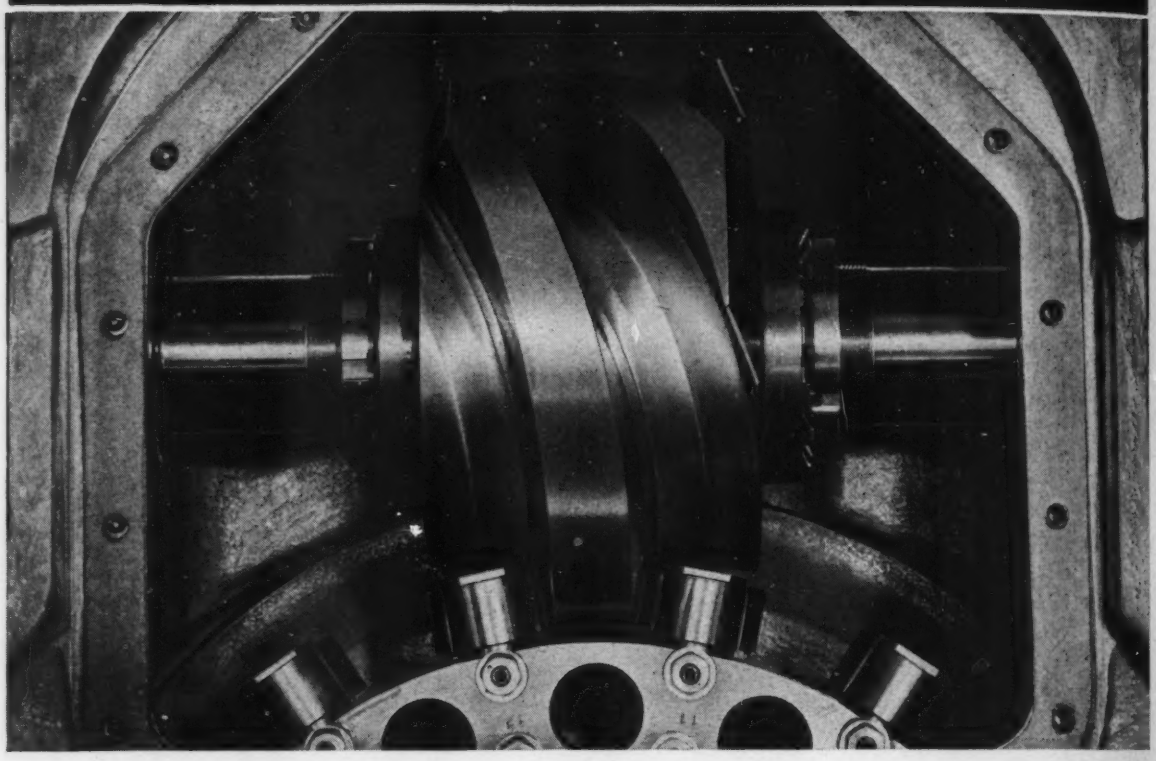
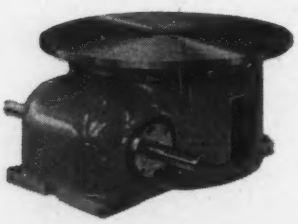


The mechanism shown above is a **MANIFOLD MARK II UNIT** as used in the pharmaceutical industry. It consists of two co-operating elements, the driven member being a turret which bears a number of radially arranged and equally spaced rollers. The driving member is a cam of concave globoidal shape and is similar in principle to a worm of which part of the thread is straight and the remainder forms a helix of varying pressure angle.

When the rollers are engaged with the straight section the turret is rigidly held and a "dwell" period occurs. The turret is indexed when a roller moves through the curved section.

The simple design and extreme accuracy of manufacture of the Mark II Units enables speeds as high as 750 cycles per minute to be obtained.

Provision is made for a wide variety of applications with as few as 4 "stops" for each complete revolution of the dial-plate.



ROTARY TRANSFER UNITS

fitted with Mark II Indexing Mechanisms with a wide range of stops and indexing angles are also available. When the unit is used in machines required to have a variable dwell time, clutch-brakes may be readily incorporated to effect a "Stop-and-Start" behaviour of the cam-shaft.

Charts are available showing a selection from the standard range of Mark II Indexing Gears and particulars of the Manifold Mark I Systems.

For further information
Telephone ENField 5353

MANIFOLD MACHINERY COMPANY LIMITED
SUFFOLK WORKS, 660 GREAT CAMBRIDGE ROAD, ENFIELD, MIDDLESEX

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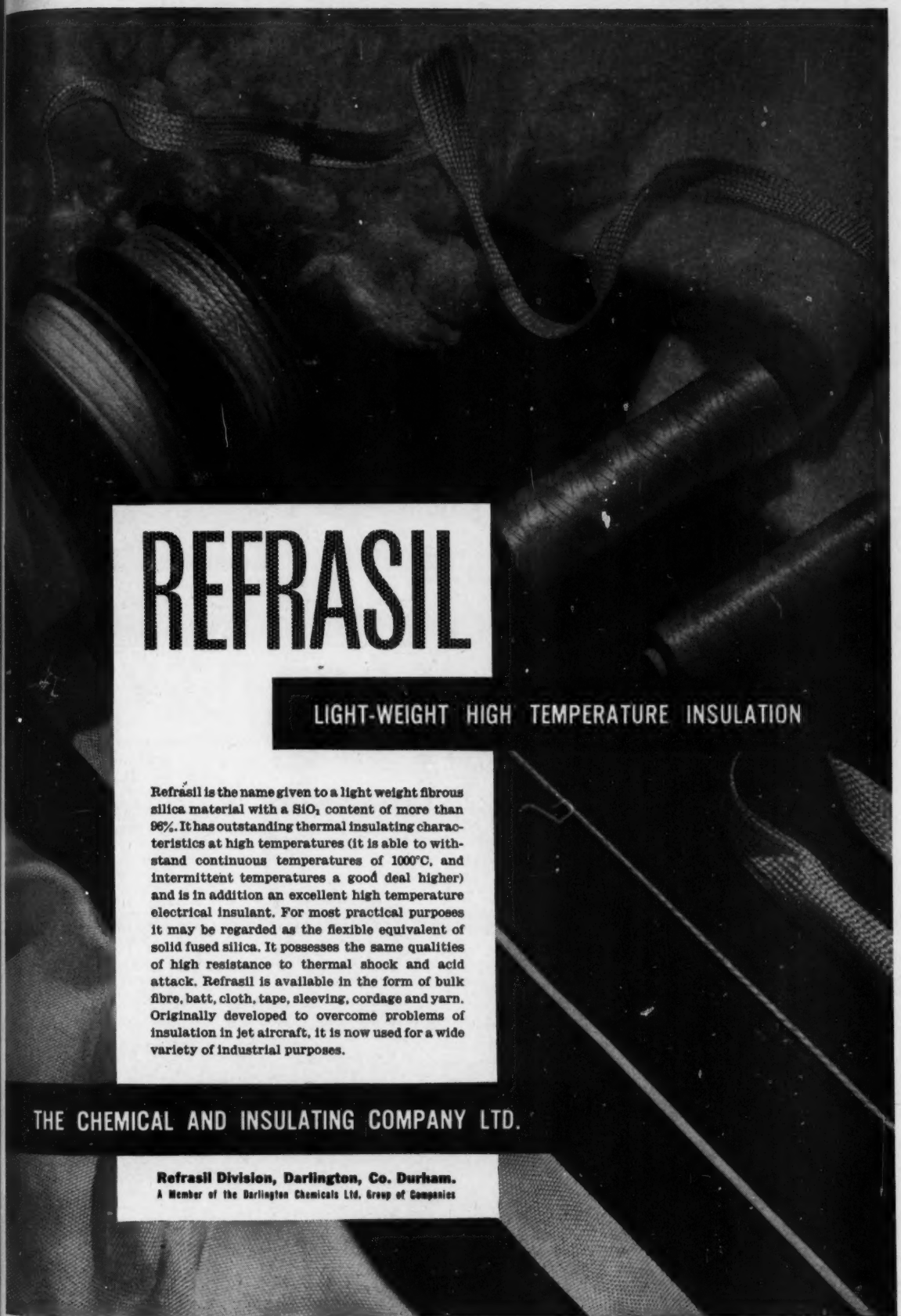

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Refrasil Division, Darlington, Co. Durham.
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who forgot the oil?

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What is D.U.?
D.U. consists of a tin-plated steel backing on which a thin layer of porous bronze is laid. This is impregnated with a mixture of lead and fluoro-carbon known as FLUON.*

D.U. combines all the advantages of these materials, including resistance to wear, low friction and anti-adhesiveness, high thermal conductivity, low thermal expansion, high mechanical strength, wide service temperature range — from − 200° to + 280° C — resistance to abrasive atmospheres, elimination of contamination, and the ability to run submerged in liquids — often with improved performance.

* An I.C.I. Trade mark.

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Write for this FREE Handbook (No. 2) which gives all data on D.U. and D.Q. Dry Bearings and materials, as well as D.G. and D.L. process treatments.

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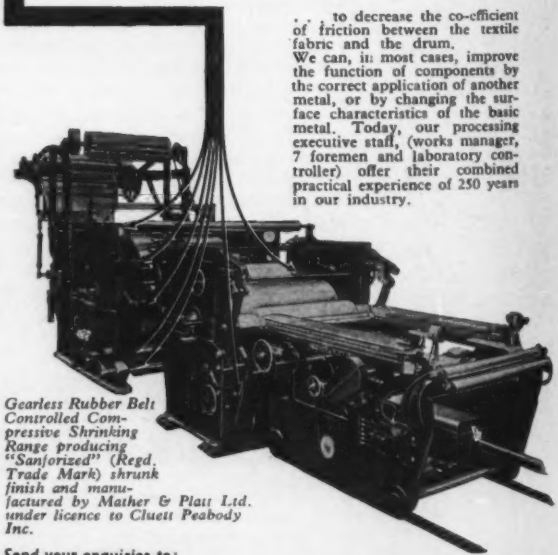

Gearless Rubber Belt Controlled Compressive Shrinking Range producing "Sanforized" (Regd. Trade Mark) shrunk finish and manufactured by Mather & Platt Ltd. under licence to Cluett Peabody Inc.

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glass reinforced plastics

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Specialists in press moulding, J. W. Roberts Ltd. have recently expanded with growing demands of industry and can now produce FEROGLAS components in a wide variety of sizes and shapes—*to meet individual requirements.*

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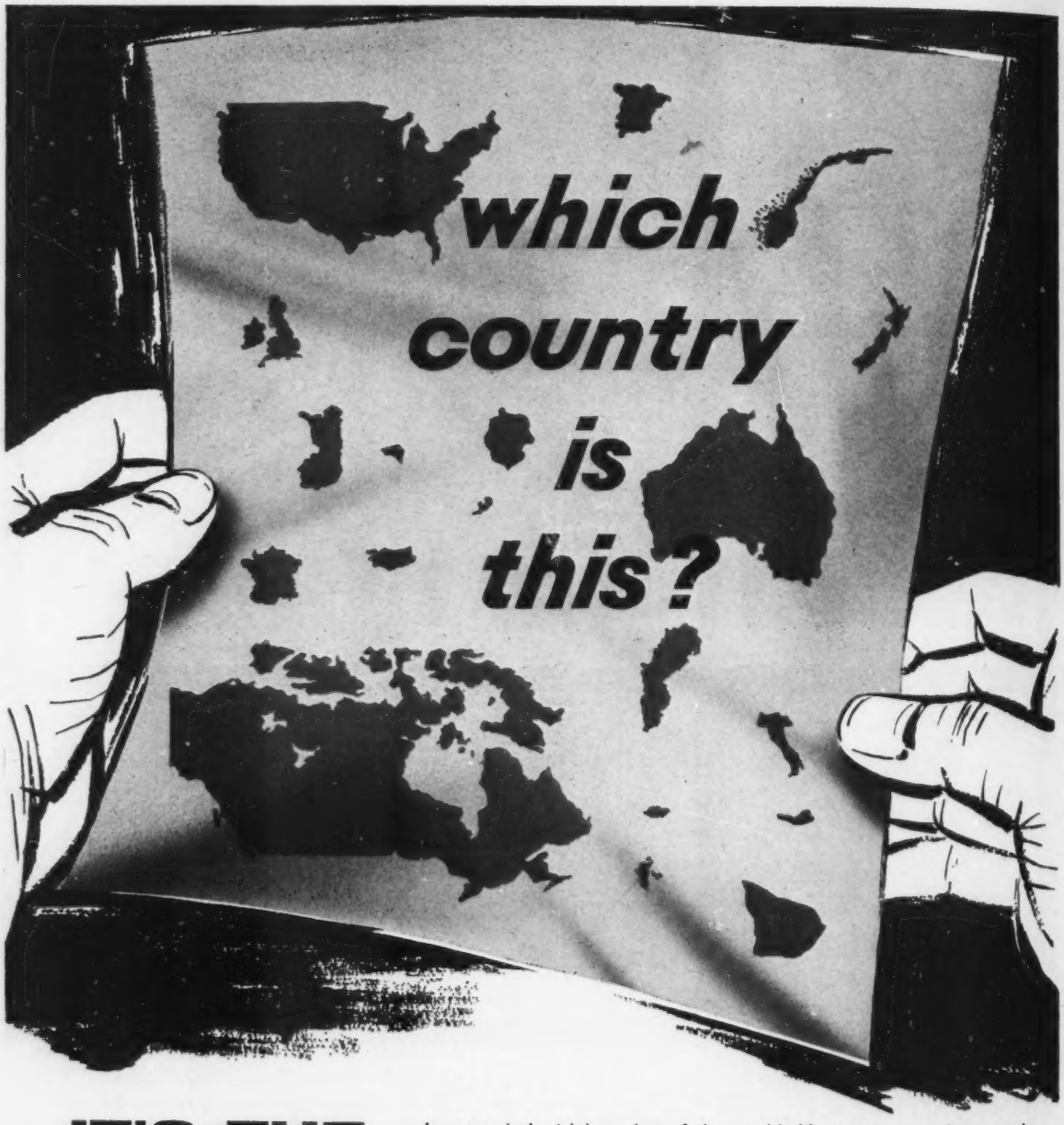
J.W.R.47



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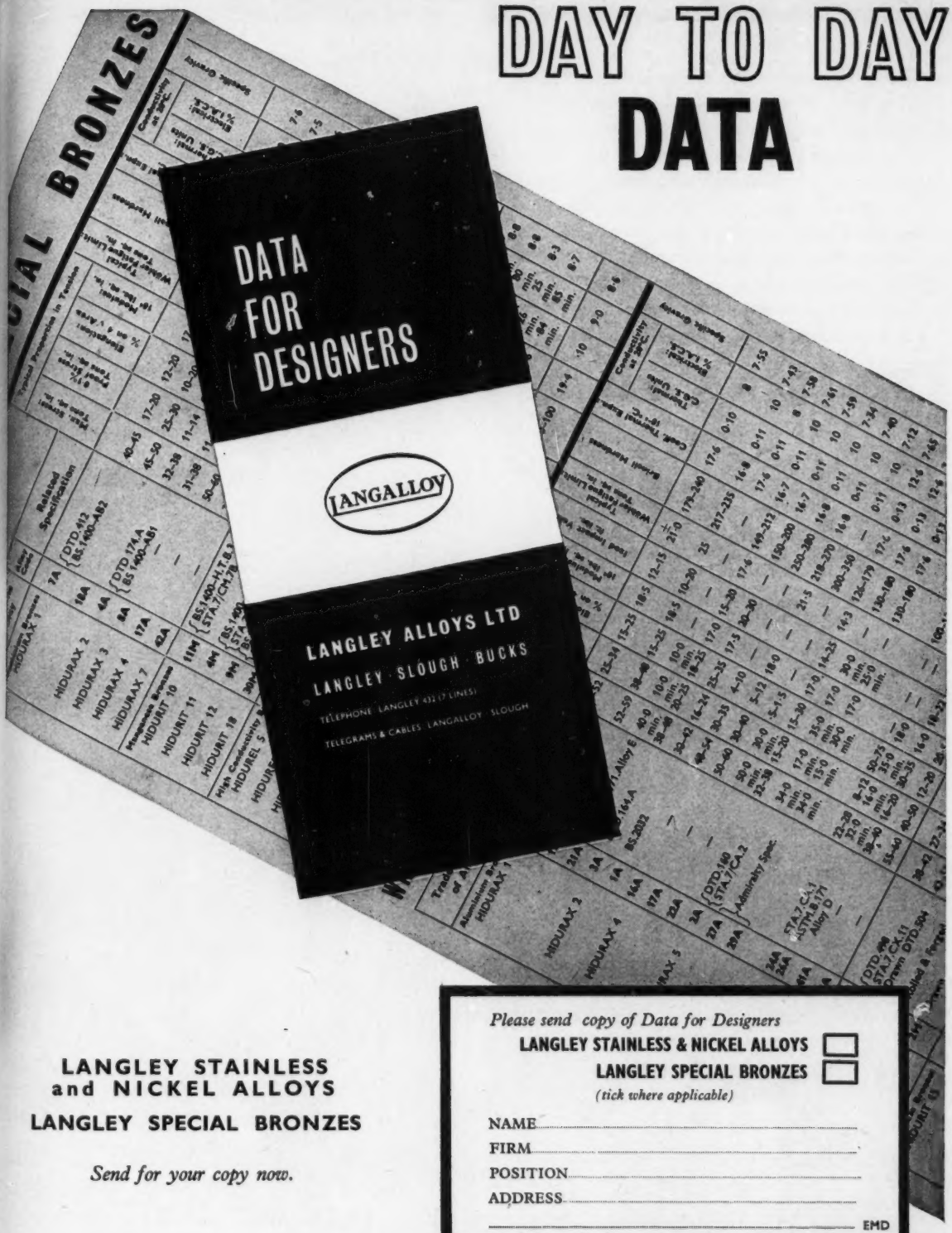
EMD 8267 for further information

DAY TO DAY DATA



LANGLEY STAINLESS and NICKEL ALLOYS

LANGLEY SPECIAL BRONZES

Send for your copy now.

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LANGLEY STAINLESS & NICKEL ALLOYS ☐

LANGLEY SPECIAL BRONZES ☐

(tick where applicable)

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EMD

LANGLEY Special ALLOYS

LANGLEY ALLOYS LIMITED

LANGLEY · SLOUGH · BUCKS

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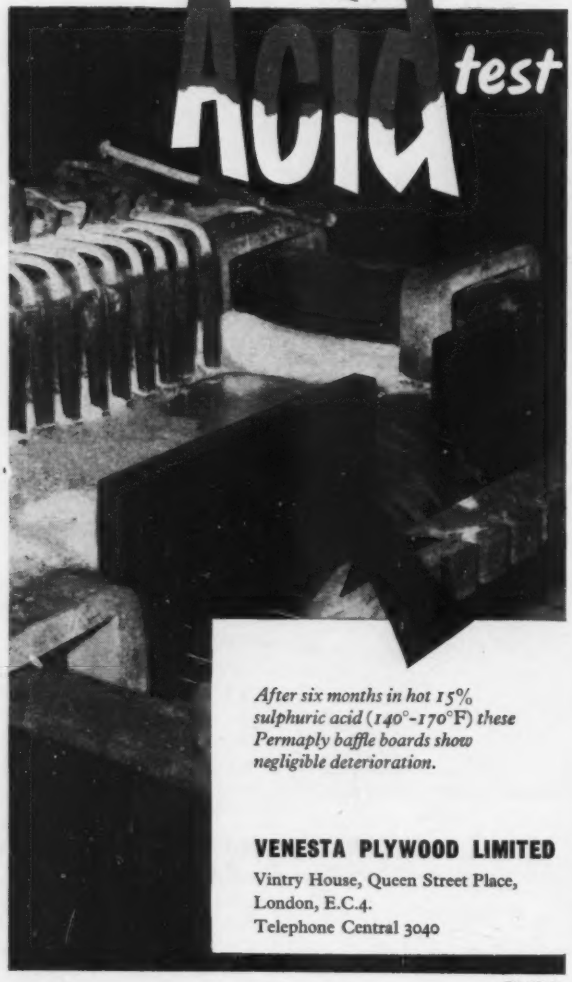
One-inch Permaply baffle boards continue to stand up to hot sulphuric acid in these galvanising cells, where solid teak, ebonite and other materials soon fail. Rylands Bros., Ltd. one of the largest manufacturers of galvanised wire, found this resin-impregnated plywood cheaper, more convenient and far more durable than any other material. For the same reasons, Rylands also use Permaply as covers for tanks containing hot acidic zinc sulphate solutions. Send for full technical information about the remarkable resistance of Permaply to all forms of attack.

Permaply

RESIN-IMPREGNATED PLYWOOD

passes the Acid test

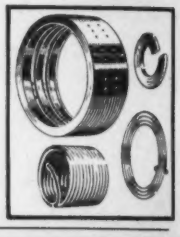


After six months in hot 15% sulphuric acid (140°-170°F) these Permaply baffle boards show negligible deterioration.

VENESTA PLYWOOD LIMITED
Vintry House, Queen Street Place,
London, E.C.4.
Telephone Central 3040

TA 5094

Outstanding for precision and reliability, Cross wire thread inserts, coils, rings and spring washers have won world wide renown. Manufactured in high carbon steel, stainless steel and bronze to suit any specific application.



CROSS Mfg. Co (1938) Ltd.
Combe Down, Bath. Tel: Combe Down 2355/8.

All kinds of cars consult Phoenix about their vibration troubles!

Whatever your engineering field—if you have a vibration problem, you too should call in

PHOENIX For rubber to metal bonded anti-vibration units designed by Getefo of Germany

Phoenix Rubber Co. Ltd. Slough, Bucks. • Telephone Slough 22307/9
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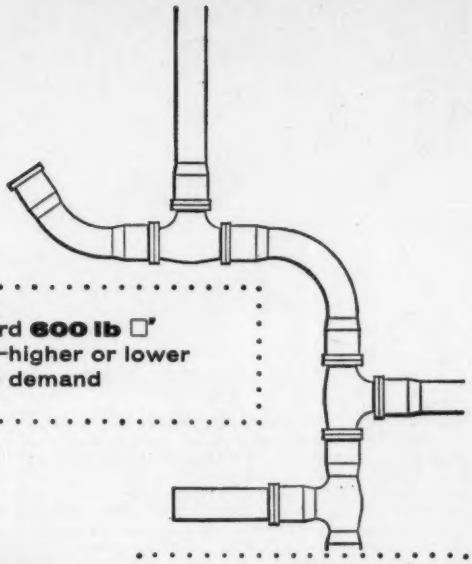
mirror-smooth bore
boosts throughput

less expensive than
stainless steel



standard **600 lb** □"
pressure—higher or lower
on demand

4 in - 36 in
nominal bore
up to 20 ft lengths

strong as steel
... 75% **lighter**

EPOCH PIPING SYSTEM

versatility . . .

Evolved, developed and perfected by BAPL, EPOCH high-strength wound glass reinforced epoxy pipes are an 100% efficient answer under critical conditions where metal pipes corrode, where installation costs have previously been high or where prefabricated systems have especial advantages. The EPOCH system, with its comprehensive range of nominal bores and fittings, can be simply and rapidly installed to follow any predetermined contours. We invite enquiries from organizations where piping installations are an important and recurring factor of their operations.

This composite illustration is indicative of the adaptability possible with the standard range of EPOCH joints and unions.

"EPOCH" is the trade-mark of Bristol Aeroplane Plastics Limited

Enquiries to— **BAPL** **BRISTOL AEROPLANE PLASTICS LIMITED**

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NOW . . .

STAINLESS STEEL TUBING

from three to twelve inch diameter

IN UNLIMITED-LENGTH STRAIGHTS

automatically and continuously welded

AT GREATLY REDUCED PRICES

Advanced fabrication methods now enable us to offer unlimited-length straights in stainless steel tubing at lower prices. Reductions are in the order of approximately 30/40% for 3" tubing, 15% for 10" tubing, 6% for 12" tubing. The greater strength and durability of stainless steel allows reduced wall thicknesses, resulting in greater economy. Bore sizes from 3 to 12 inches can be delivered more speedily due to new production techniques. Automatic welding is continuous and electronically controlled to micro-metric accuracy, thus eliminating bacteria-harbouring crevices and ensuring a remarkably high degree of clinical purity.

All bore sizes are subjected to stringent pressure tests, far in excess of possible working requirements. E.g., 3" bore, tested to 1,000 lb. p.s.i.; 12" bore, tested to 500 p.s.i.

Weights and Dimensions in lb. per foot

TRUE BORE

Bore	20 swg.	18 swg.	16 swg.	14 swg.	12 swg.	10 swg.	8 swg
3"	1·23	1·63	2·16	2·71	—	—	—
4"	1·64	2·16	2·86	3·60	—	—	—
6"	2·46	3·22	4·29	5·35	6·99	—	—
8"	—	4·28	5·69	7·13	9·32	—	—
10"	—	—	7·10	8·89	11·61	14·31	—
12"	—	—	—	10·64	13·94	17·11	21·46

NOMINAL BORE

3"	1·42	1·83	2·40	2·99*	—	—	—
4"	1·82	2·34	3·13	3·87*	—	—	—
6"	2·68	3·50	4·61	5·76	7·48*	—	—
8"	—	4·57	6·04	7·55	9·81	—	—
10"	—	—	7·53	9·40	12·23	15·0*	-
12"	—	—	—	11·15	14·56	17·82	22·20*

*ASA Schedule 5.

Welding Technical Services Ltd.

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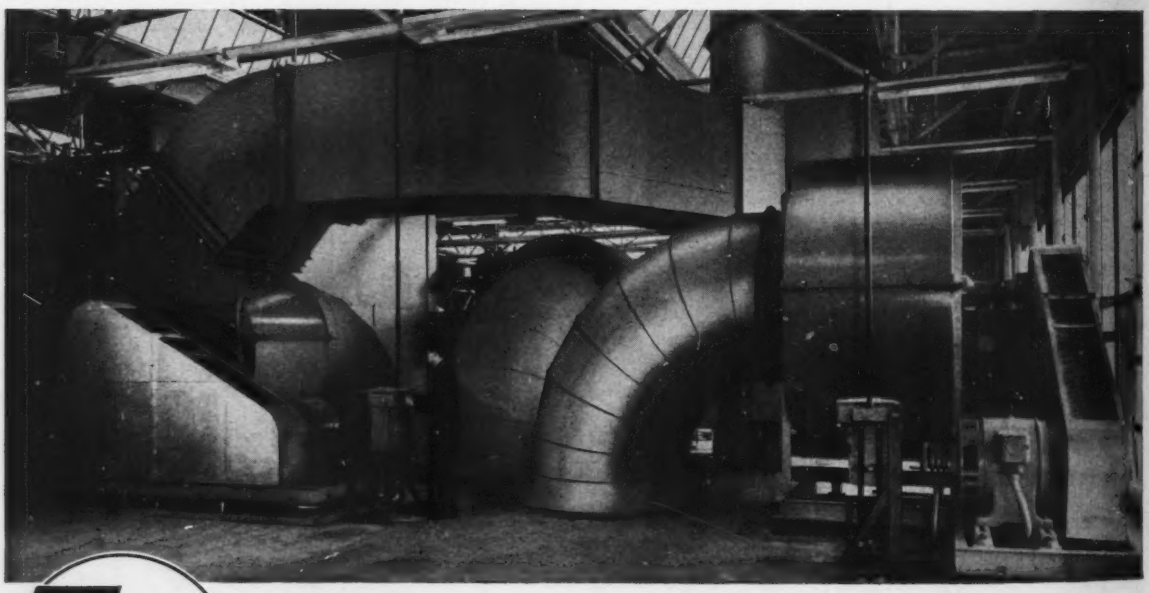

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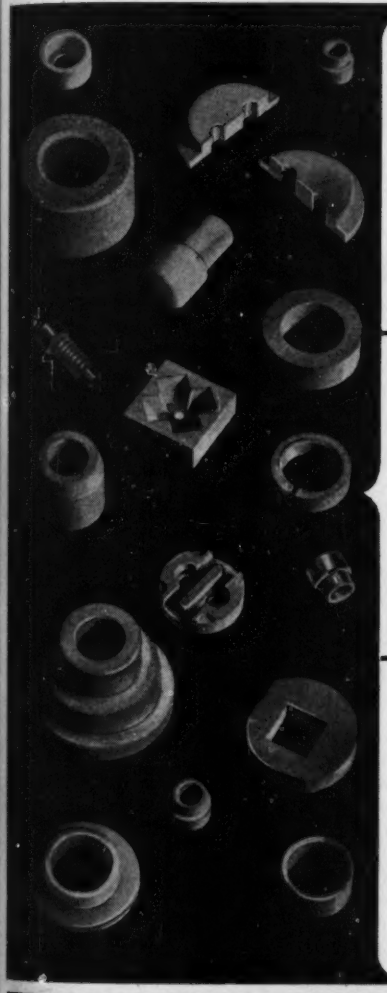
HIGH QUALITY DIELECTRIC

MATERIALS FOR THE ELECTRONIC & ELECTRO-MECHANICAL INDUSTRIES



FLUOROCARBON T.F.E. (P.T.F.E.)

Extruded and moulded Rod, Thin Wall Tubing and sleeving, Sheet, extruded and moulded Tube, Tape, and Machined Parts.

WITH THESE ADVANTAGES:

Electrical

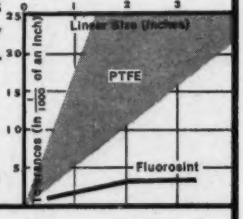
- High dielectric strength
- Extremely low loss factor
- High volume and surface resistivity
- Low dielectric constant

Mechanical

- Very low co-efficient of friction
- Non-adhesive
- Easily blanked or machined

FLUOROSINT* T.F.E.

A new P.T.F.E. base resin produced only by Polypenco Ltd., providing outstanding compressive strength, rigidity and wear resistance, whilst retaining all the electrical advantages inherent in P.T.F.E. Added advantages are considerably lower coefficient of thermal expansion and improved dimensional stability.



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* Regd. Trademark, Patented

Tolerances achieved in tests on FLUOROSINT mouldings indicate their use where PTFE parts will not meet the requirements.

Q.200.5 CROSS-LINKED POLYSTYRENE

A clear, rigid, dimensionally stable material with outstanding performance as an U.H.F. insulator up to 10,000 Megacycles. Q.200.5 is readily machineable on orthodox metal working equipment.

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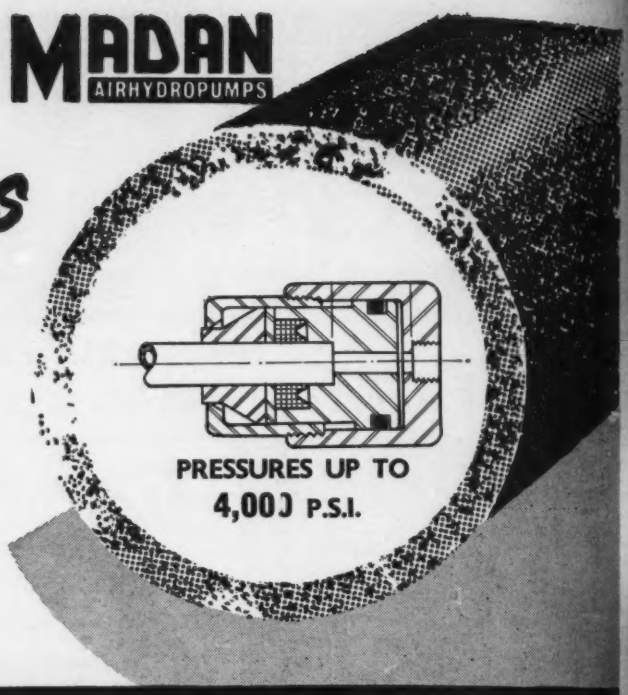
MADAN AIRHYDROPUMPS

- "QUICK ACTING" PRESSURE OPERATED
- FOR TESTING TUBES WITH PLAIN ENDS
- TO PRESSURES UP TO 4,000 P.S.I.
- AVAILABLE IN SIZES FROM ¼" O/D – 1½" O/D INCLUSIVE



Suitable for use with tubes in all materials and the testing of flexible hose units with standpipe ends.

The couplings will withstand pressures up to 4,000 p.s.i. throughout the period of the test and are immediately detachable upon release of the hydraulic pressure within the tubing.

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for

- FOR FAST, ACCURATE INDEXING
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Machine designers will appreciate the versatility of the Renold Sprag clutch which, with its full complement of precision made sprags self-contained between concentric races, **transmits more torque for size and weight than any other clutch.**

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RENOLD CHAINS LIMITED
REPRESENTATION THROUGHOUT THE WORLD

SUCCESS

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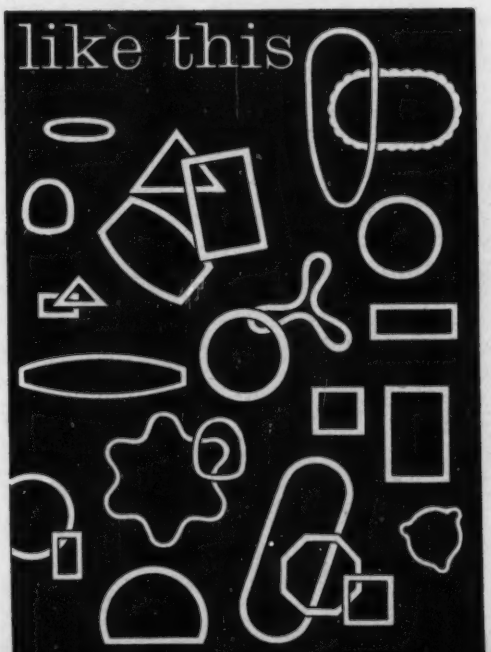
could depend on precision like this



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Progress in the conquest of distance and time so often depends on the availability of the right material for a vital component.

JMC PRECISION TUBES, in specialised non-ferrous metals, make a significant contribution to many advances in science and industry. For, irrespective of shape, size or alloy, their accuracy of both composition and dimension ensures a basic material of the utmost reliability.

Full information is available on request.

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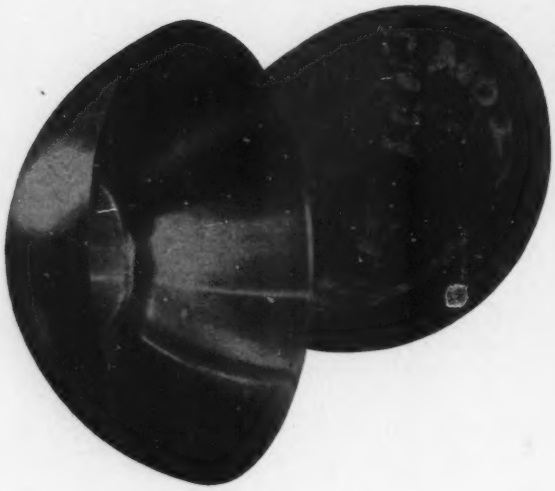

This bowl is an atomiser disc, for a specialised chemical plant. It needed to be highly resistant to corrosion, to be very strong, yet very light (it spins at high speeds) and it had to be machined to high standards of precision. The chosen material was titanium, a material requiring special technique in forging. The Daniel Doncaster companies undertook the work; the titanium forging was made at Doncaster's works in Sheffield and the precision machining and final balancing was carried out by Moorside Components at Oldham.

A typical example of the integrated skills and equipment which this group of companies can bring to your problems.

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OLDHAM

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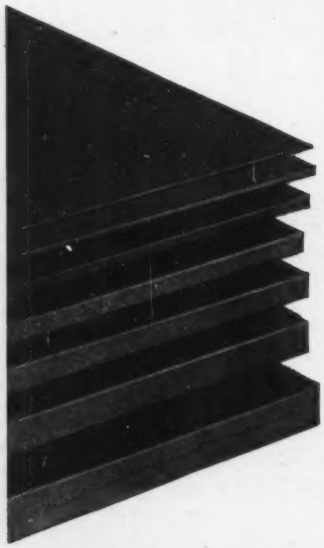
Synthetic Resin Bonded LAMINATES

For silent gears and pinions, bushes, washers, bearings and small mechanical parts . . . for jigs . . . for electrical control panels, terminal boards, etc. Formapex has special advantages—high strength/weight ratio, high dielectric strength, low coefficient of friction, great resistance to heat, moisture, weak chemicals, etc.



FORMAPEX

Formapex is supplied in sheet form, in various fabric and paper base grades. It can be machined and punched, and there are grades to meet all appropriate British Standard, N.E.M.A. D.I.N. Specifications.

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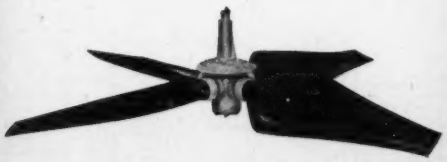
THIS fan cuts cooling costs



'MAREX' INDUSTRIAL FANS

'Marex' hollow plastic industrial fans set an entirely new standard of efficiency for process cooling and ventilation. The aerodynamically designed resin/fibreglass blades weigh less than a quarter as much as most fan blades with the same air-handling capacity—but they're so tough that they won't fragment or shatter, or corrode in acid-laden air. Installation is easy, and an auto-variable-pitch hub gives you automatic control of the blade pitch while the fan is in motion (manually adjustable-pitch hubs are also available.)

'Marex' fans are made by Marstons, sole licensees in Britain of the Hudson Engineering Corporation of Houston, Texas, and are available in overall diameters ranging from 6—14 ft. in increments of 1 ft.

Write now for the Marston leaflet giving performance data for the complete range of 'Marex' fans.

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FOR BUSHES, BEARINGS, GEARS, VALVES

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UP TO 6 1/16" DIAMETER
NO BLOWHOLES, NO POROSITY

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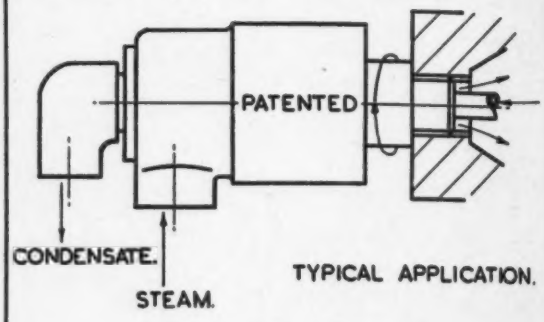

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For steam, water, air, oil, etc.,

Standard sizes 1/4"—3" B.S.P.
Specials up to 6 1/2" nominal bore

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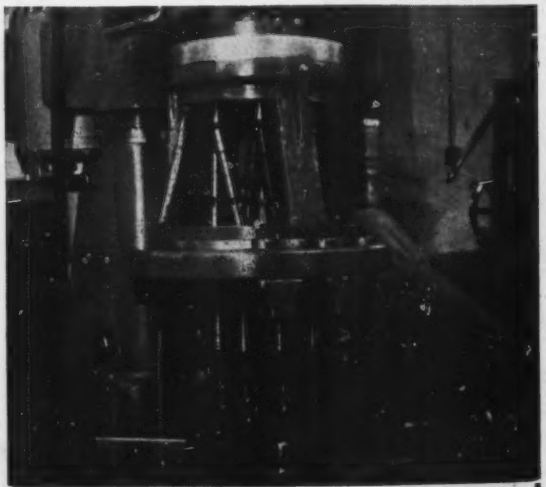

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Old time, using single spindle drill . . . 3 mins. 30 secs.

New time, using S.P.K. equipment . . . 1 min. 21 secs.

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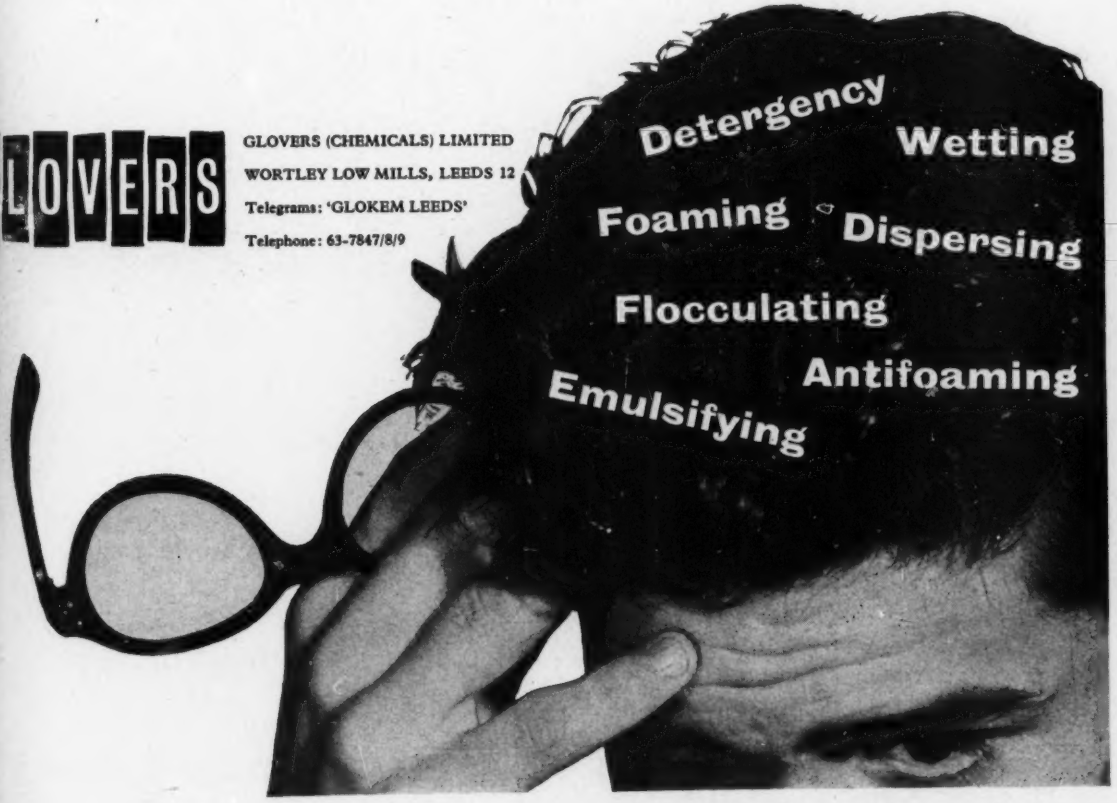

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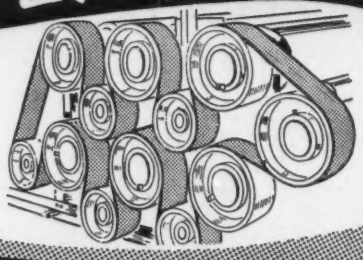
STEPHENS Miraclo

The best belt for EVERY drive



If you require a top performance lightweight flexible belt that won't slip, has enormous strength and elasticity with virtually no stretch, and with the grip only chrome leather can give, then you need a Miraclo nylon-core belt

FREE Send for this new 12 page colour brochure 223 which fully explains in word and picture the Miraclo Nylon-Core Belt — the Belt that performs miracles.

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A heavy duty pipe coupling giving zero leakage under conditions of extreme temperature and pressure. Ideal for heat transfer systems, pressure and vacuum lines and cryogenic systems.

KING THINWALL TUBE

Seam welded under inert gas conditions to eliminate oxidation and provide an ultra-smooth finish. Burst pressure of 2,200 p.s.i. for 1" diam. Made from stainless steel in ¼", 1", 1½" and 2" bores.

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VEE BAND CLAMPS

The many advantages offered by King Vee Band Clamps—positive sealing, quick release, low envelope, low weight, etc.—make them an automatic choice for pipes, ducts and containers. Vee Band Clamps can be manufactured to any specified diameter.

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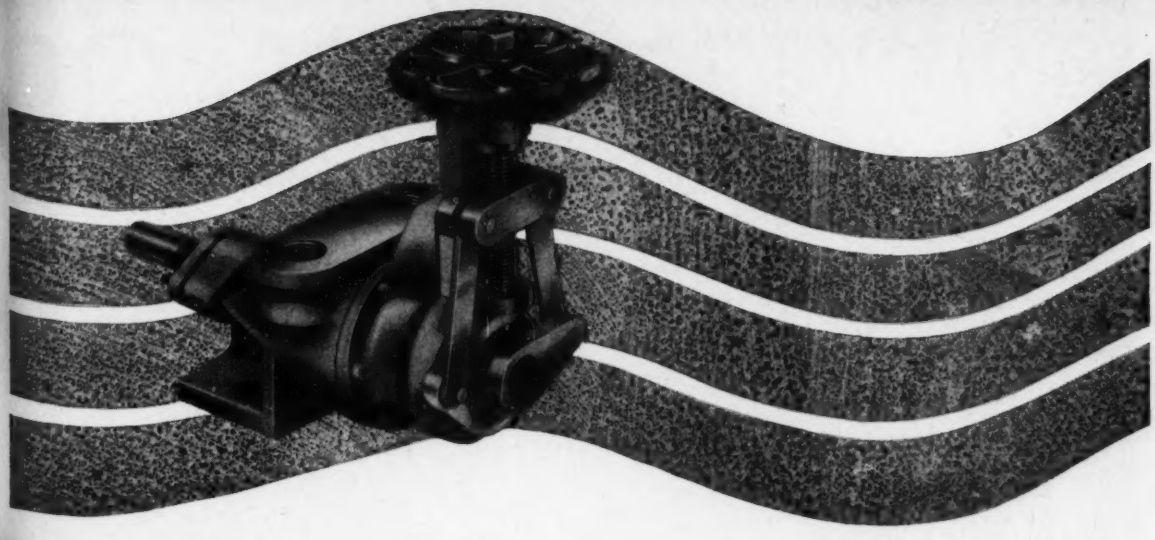

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The perfect pump for use with all lubricant fluids of a non-abrasive nature which, because of its versatility, is ideal for a wide variety of industries. Long life and reliability are built into the unique construction of the Rotoplunge, which has only three moving parts. *No other range of pumps has such a wide variety of optional features.*

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Gives infinitely variable control over the complete range with accurate indication of the setting.

SHORT STROKE

End covers providing for reduced delivery ratios of one third and two thirds are available as an alternative to variable stroke.

AUTOREVERSE

Irrespective of the direction of the driving shaft, the autoreverse automatically maintains a uniform direction of flow.

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All pumps can be fitted with a relief valve and by-pass to prevent overloading of the pump or driving arrangement.

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Available in a comprehensive range from 7.5 gal./h. to 2,300 gal./h. Flange or foot mounted for close-coupled or motorised sets. *The illustration shows a foot mounted Rotoplunge pump with variable delivery control.*

A division of the Parkinson Cowan Group

Parkinson Cowan Measurement,
P.O. Box No. 2, Dobcross, Oldham, Lancs.
Telephone DELph 424 Telex 23372

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PCM121

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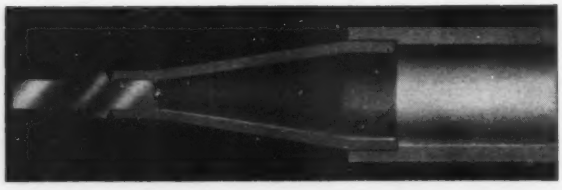
CENTRIFUGALLY Cast Tubes for Radiant Heating with SAND CAST return bands



Typical arrangement of Furnace Hearth Rollers comprising Solid Shaft—SAND CAST Heat Resisting Trunnions Fabricated into CENTRIFUGAL CAST Heat Resisting Alloy TUBE

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- have no loose parts
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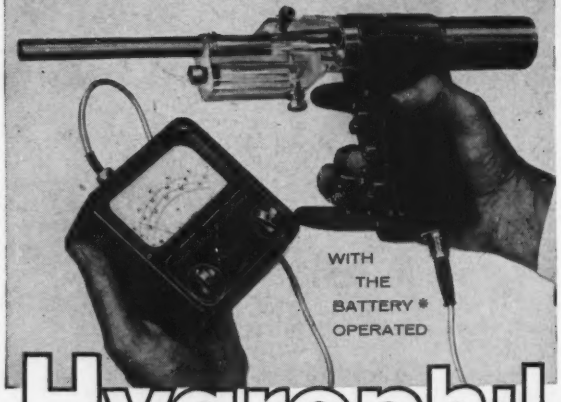

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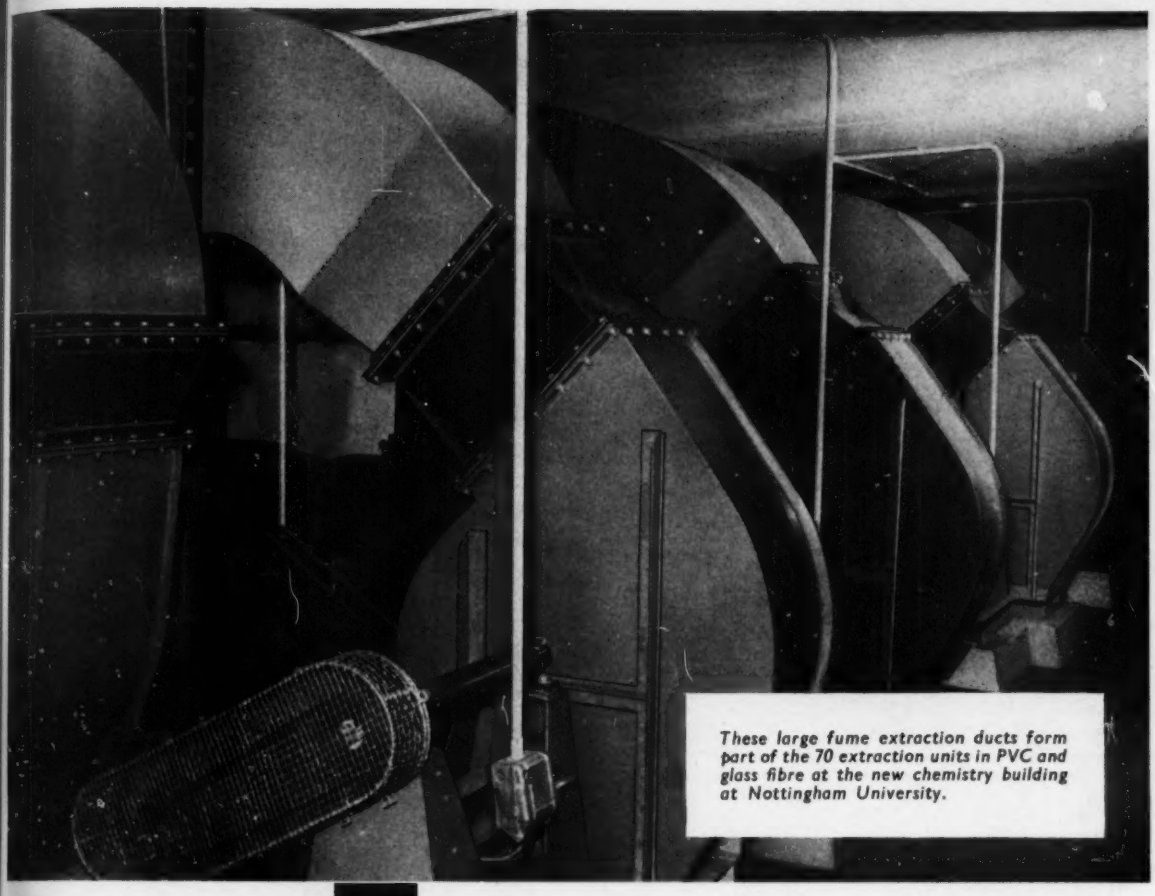

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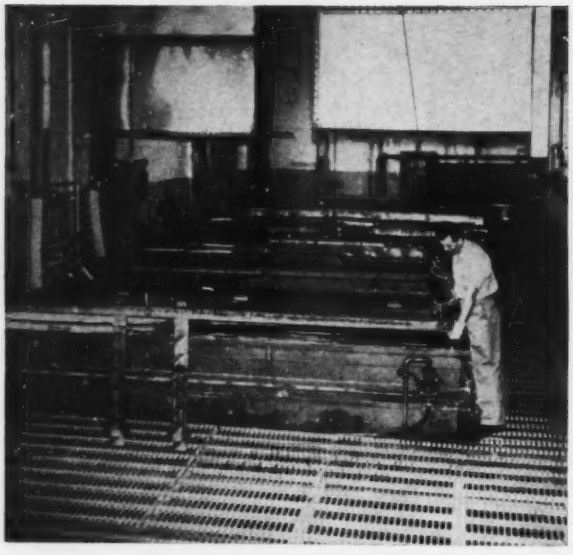

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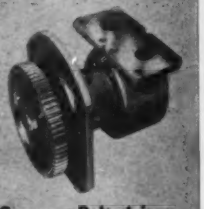

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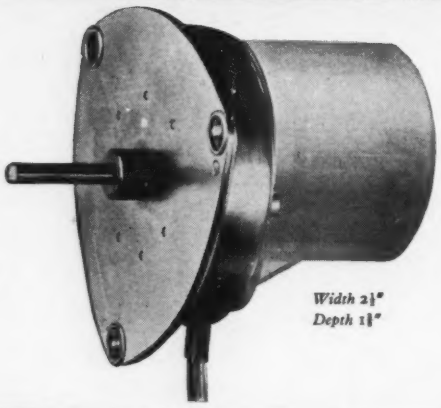

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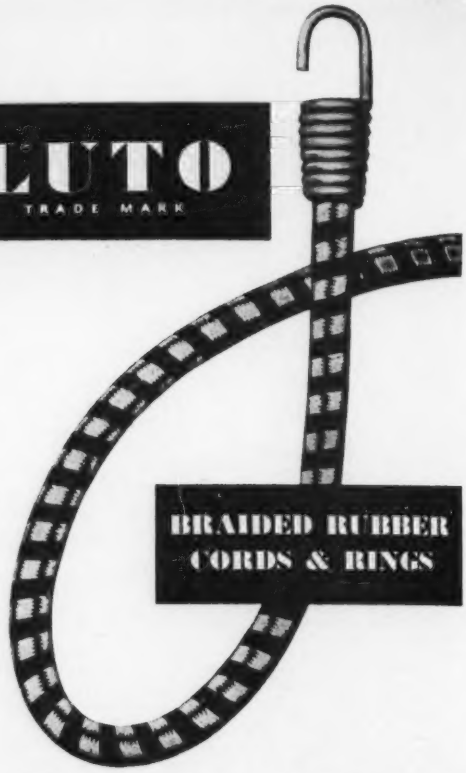

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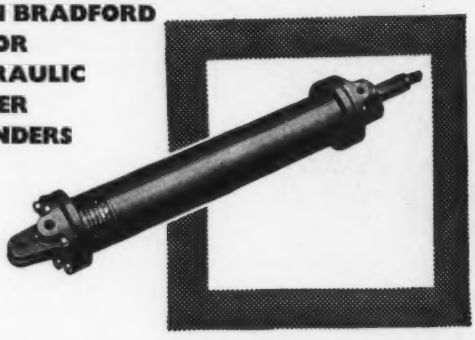

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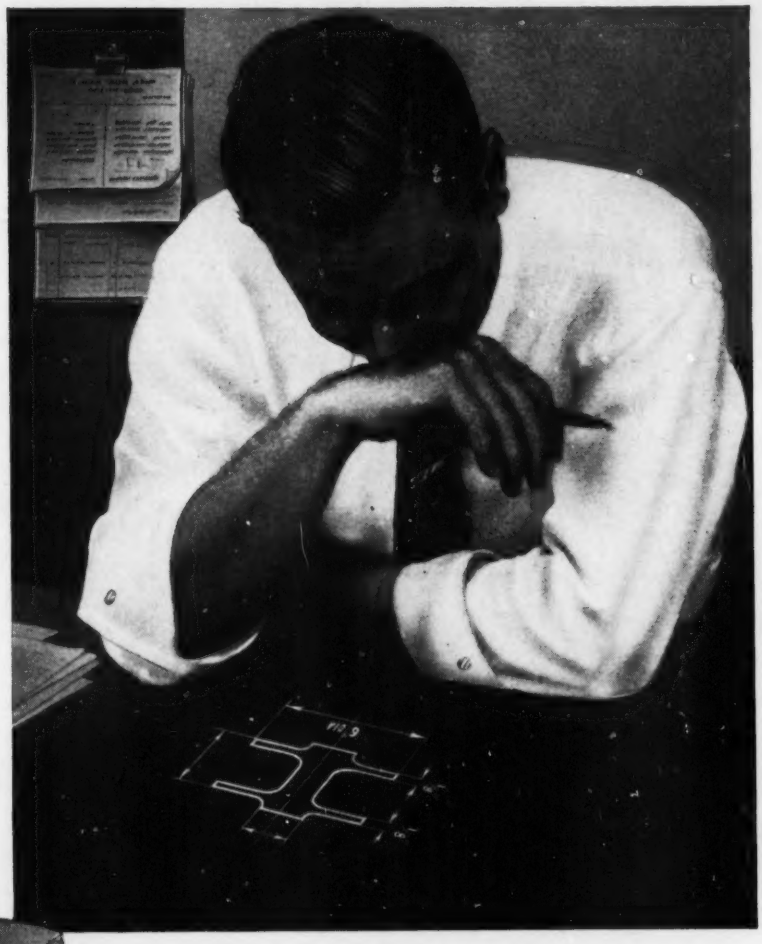

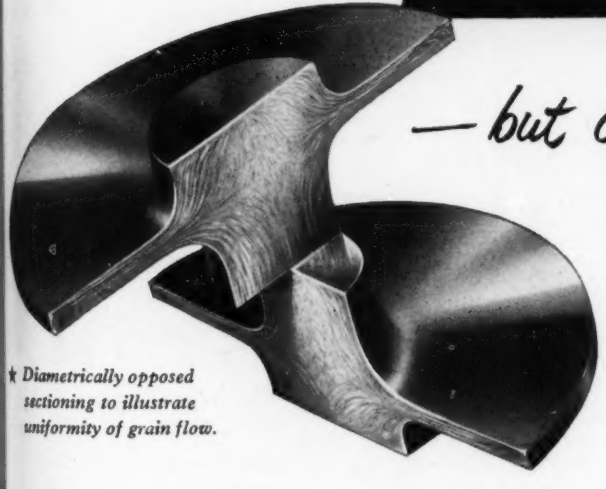

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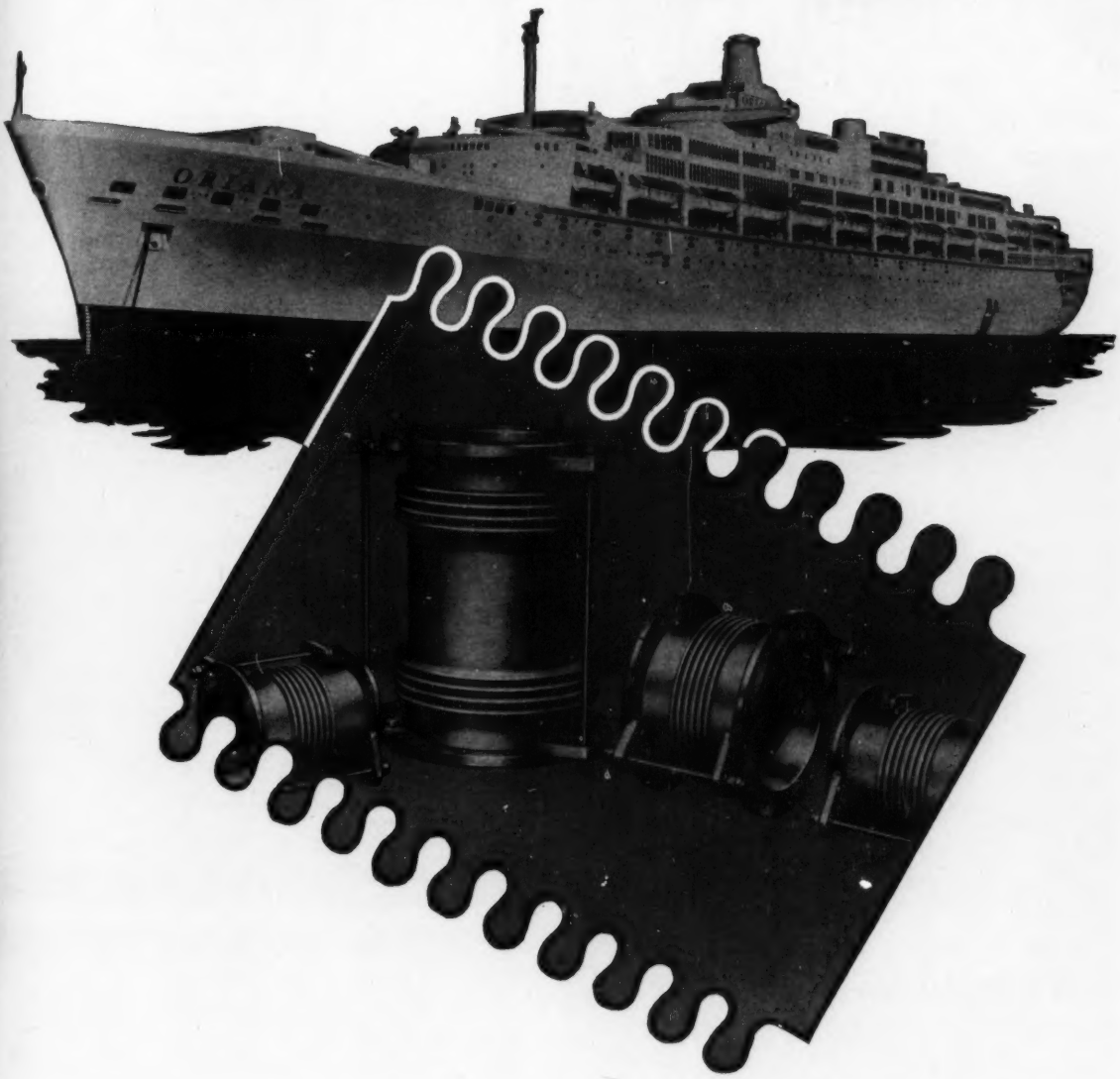

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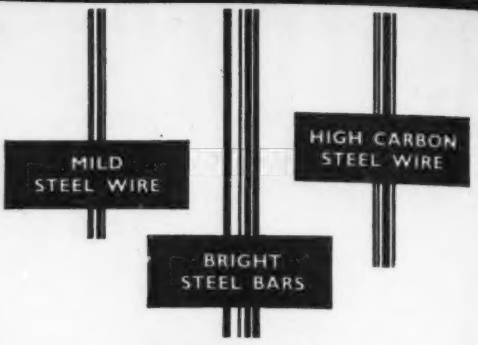

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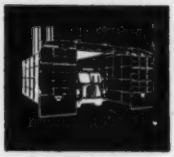

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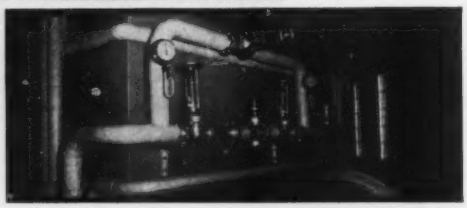

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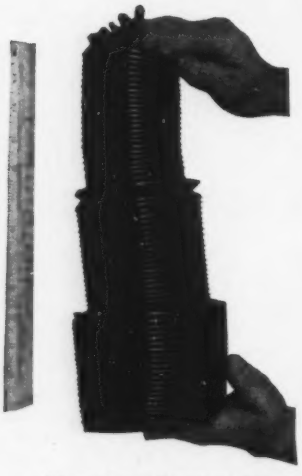

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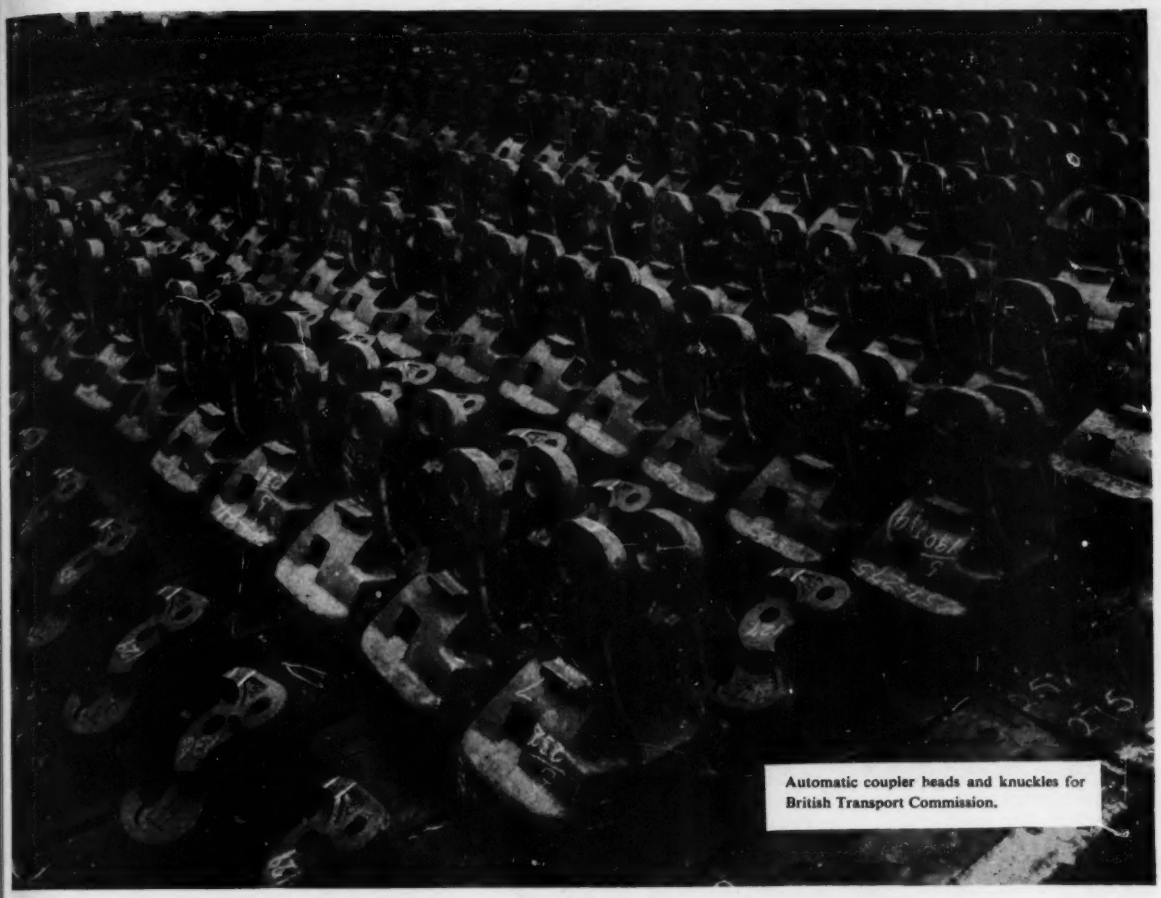

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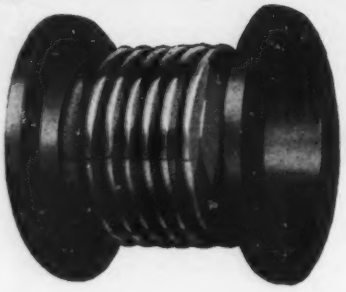

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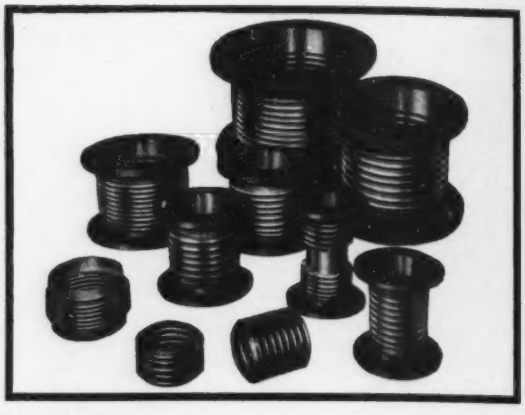

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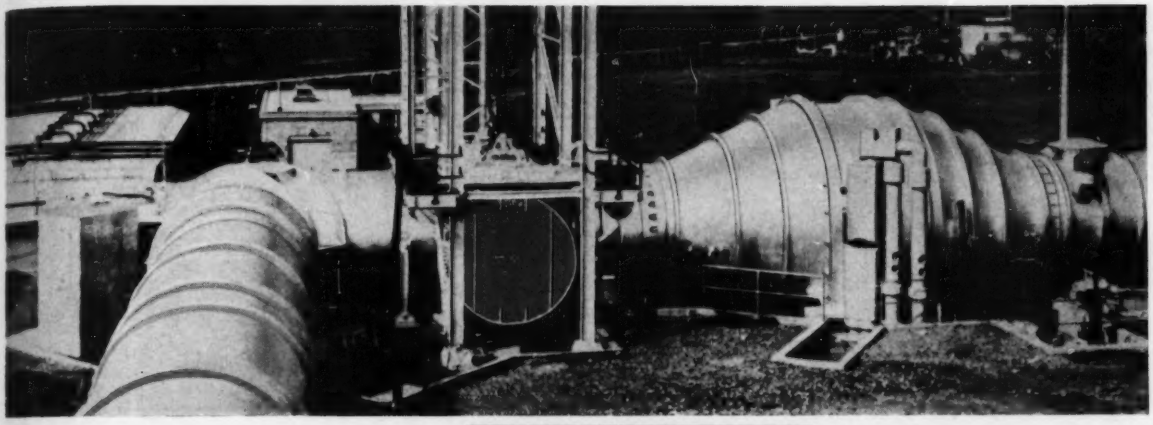

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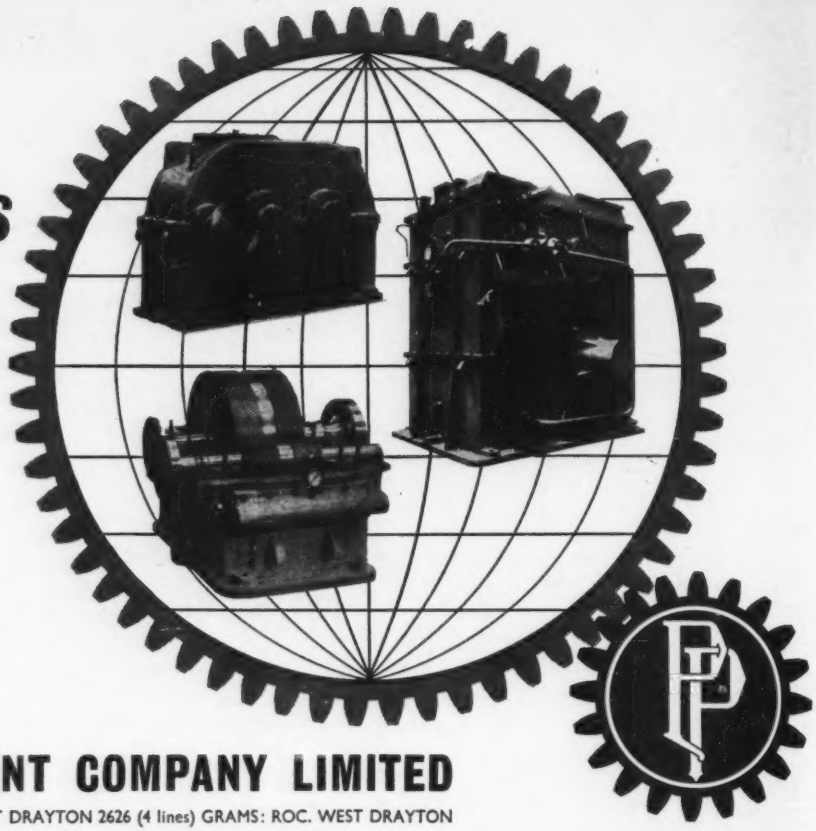

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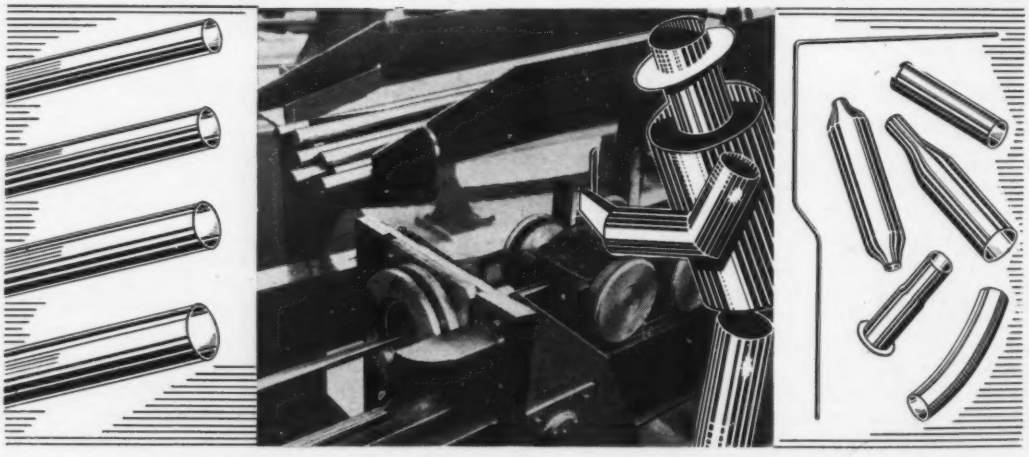

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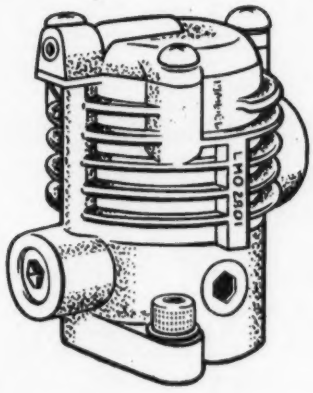

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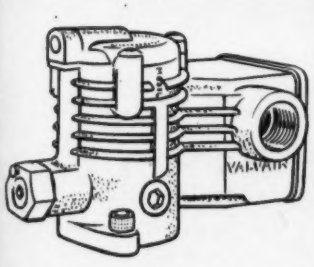

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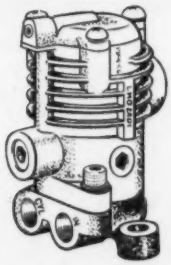

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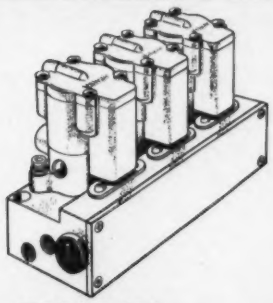

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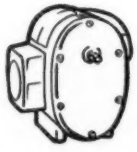

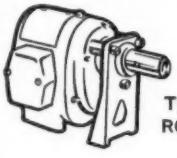

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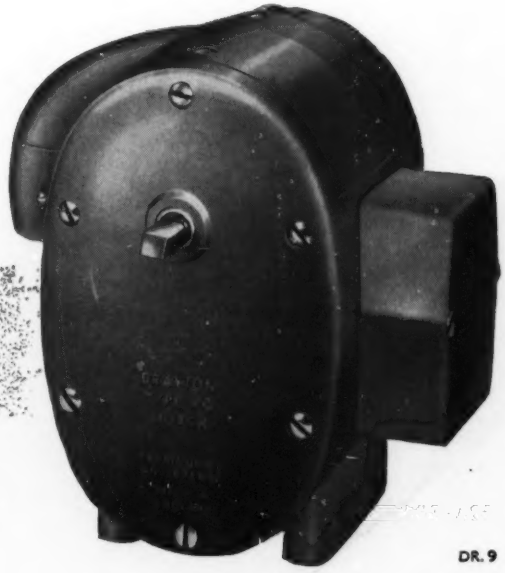

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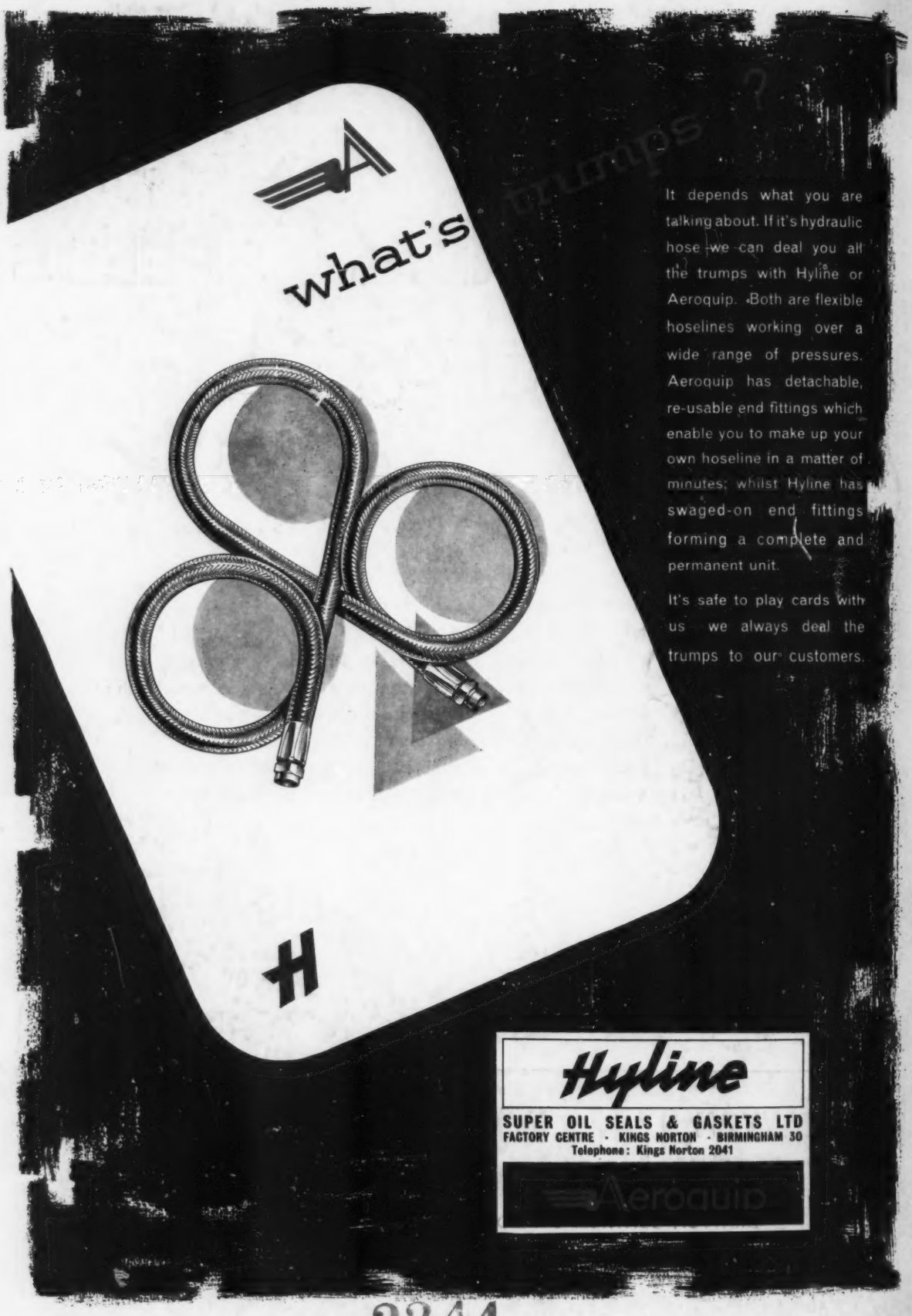
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